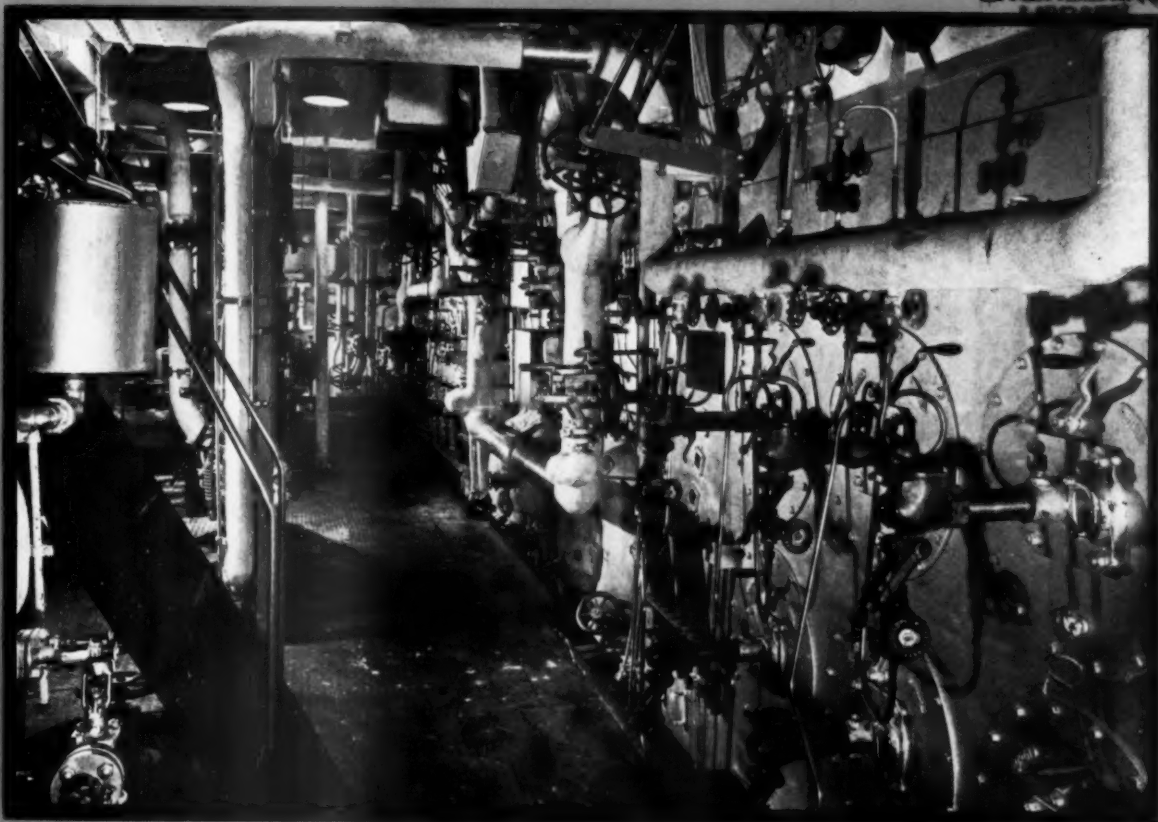
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

April 1953



Boiler operating aisle in the S. S. "Old Colony Mariner", one of a class of 35 new ships being built for the U. S. Maritime Administration

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 24 **No. 10**

April 1953

Feature Articles

Editorials

Departments

COMBUSTION publishes its annual index in the June issue and is indexed regularly by Engineering Index, Inc

GERALD S. CARRICK
Business Manager

ALFRED D. BLAKE
Editor

GLENN R. FRYLING
Assistant Editor

CARL G. UDELL
Circulation Manager

Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16
A SUBSIDIARY OF COMBUSTION ENGINEERING, INC.

Joseph V. Santry, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer

COMBUSTION is sent gratis to engineers in the U. S. A. in charge of steam plants from 500 rated boiler horsepower up and to consulting engineers in this field. To others the subscription rate, including postage, is $3 in the United States, $3.50 in Canada and Latin America and $4 in other countries. Single copies: 30 cents.

Publication Office, Easton, Pa. Issued the middle of the month of publication.

Acceptance under Section 34.64, P. L. & R., authorized by United States Post Office.

Printed in U. S. A

COMBUSTION

Editorials

What Is Readable Technical Writing?

Rapidity of technical developments and the intense pace of modern living place a premium upon the amount of time that can be devoted to reading. For engineers this problem is compounded by reason of the large and continually increasing number of technical meetings and publications.

Let us assume that an engineer has "x" minutes of reading time available each month. How can he acquire the greatest return on the investment of that time? Or in slightly different terms, how can he maximize his intellectual input in terms of comprehension and breadth of understanding?

At least three primary elements are involved in this problem: the reader, the writer and the subject matter. Secondary but no less important factors may be the motivation of the reader and his knowledge of the subject under consideration, the technical understanding and the literary skill of the writer, and the nature of the subject matter—its newness, familiarity or complexity.

On the assumption that the writer has made a conscientious effort to eliminate vague, obscure or ambiguous material, the reader must be willing to put forth the mental effort necessary for comprehending the subject matter. To expect that complex engineering developments can be grasped without such intellectual exertion is to disregard the basic nature of the learning process. Actually the instructive function is one of the most important aspects of technical writing, and the author should be conscious of its significance.

There are some types of technical writing, such as news items and promotional material, that readily lend themselves to a personalized, simplified presentation. However, there is an inherent danger in applying such techniques to significant papers on complex advances in the engineering art. It arises from the deceptive simplicity of a type of writing that allows the reader to gain a superficial grasp of a subject without achieving real understanding. In other words, ease of readability may be a misleading criterion when it comes to papers of lasting value to the engineering literature.

On the other hand, it may be pointed out that some well known scientists and authorities on technical matters have shown the ability to explain highly abstruse subjects in simple terms and in a style readily comprehensible to the average person. Among these are the writings of the late Sir James Jeans and Sir Arthur Eddington on astronomy and physics and-Sylvanus P. Thompson in his little book, "Calculus Made Easy," and other comparable works.

Readable technical writing is a product of the interaction of the reader, the writer and the subject matter. The reader who prefers what might be termed sugar-coated writing may be confusing superficial acquaintance with genuine understanding of subject matter. To obtain the greatest return on an investment of reading time requires willful mental effort on his part. It is in this manner that technical writing is transformed into usable personal knowledge.

Selling an Industry to Young Engineers

Much attention is currently being given to the relative shortage of young engineering graduates. Although there has been an appreciable decrease in the numbers turned out annually by the colleges and technical schools, it is the marked increase in the requirements of industry that has emphasized the situation. In fact, one has only to scan the want ads in the Sunday editions of metropolitan newspapers to become convinced of the widespread demand for engineers of all ages and types. Industrial expansion and defense work have been largely responsible. One aspect, traceable to the law of supply and demand, is that the economic status of the young engineering graduate has been greatly improved—in many cases out of line with that of more experienced members of the profession.

Competition from some of the newer and more intriguing industries, such for instance as electronics, plastics, and aviation, have made it more difficult for the long-established industries to attract young engineers. They need to be resold. This applies to the utility industry, despite its phenomenal advances and the promising opportunities it offers as a future for young engineers.

In an effort better to acquaint some of next June's engineering graduates with what is going on in this field with its diversity of problems, a group of utilities cooperated to bring about a hundred seniors from different universities to the recent American Power Conference at Chicago. These young men appeared to take a keen interest in the papers and discussions which are believed to have opened up to them a new vista of the many phases of power generation. Moreover, by listening to and mingling with leaders in this field, some undoubtedly were inspired to follow their lead.

The experiment was apparently worth while and worth repeating.

Greenwich Steam Generating Station of Atlantic City Electric Co.

Advantages of a cooperative arrangement between a utility company and a manufacturing plant in the supplying of steam and electric power are mentioned in this description of a station located along the Delaware River. Special consideration was given to water treatment because of 100 per cent makeup requirements. Control of the turbine-generator under emergency conditions is quite different from usual central-station conditions.

By V. J. FEENEY

Project Engineer, Burns and Roe, Inc.

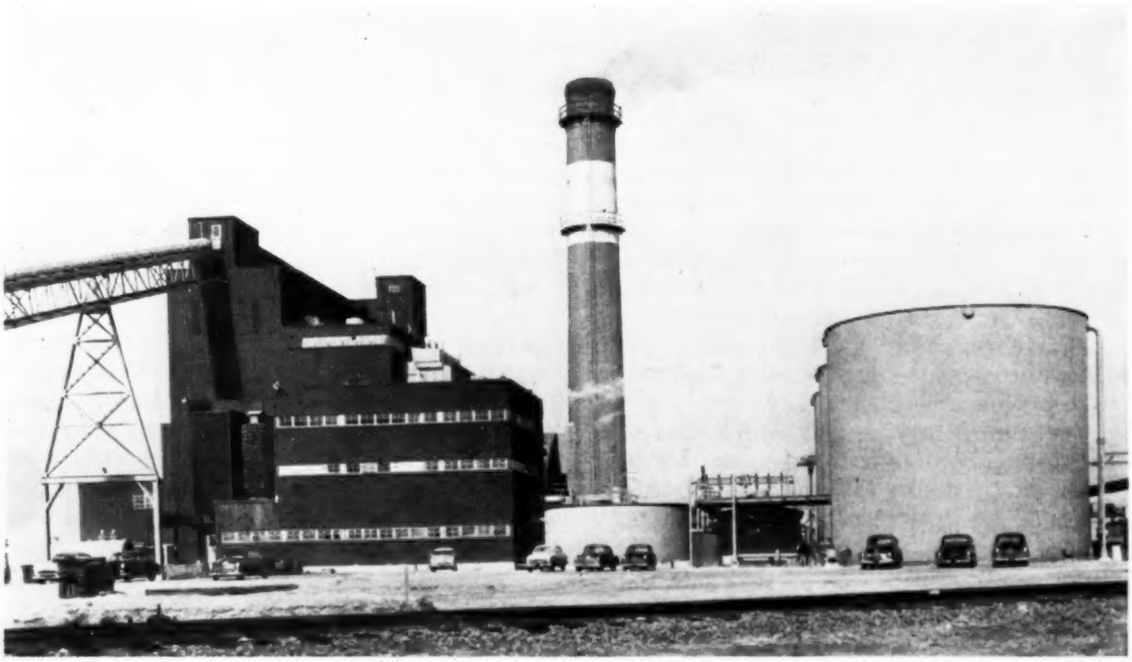
THE new Greenwich Station of the Atlantic City Electric Company located on the New Jersey shore of the Delaware River at Thompson's Point Wharf, Gibbstown, N. J., was engineered and constructed by Burns and Roe, Inc., of New York City. Engineering and design was started late in January 1951; construction, in June 1951; and the station went into operation in Nov. 1952. It supplies water, steam and electric power to the Repauno works of the E. I. du Pont de Nemours and Co. for the processing of chemicals used in the manufacture of "Dacron," their new Polyester Fiber.

A similar arrangement was started over twenty years ago, at Deepwater, N. J., when the first contract between the two companies[1] provided that du Pont would be supplied byproduct electric energy generated by the steam produced for its use. It has proved beyond a doubt that by avoiding substantial investment and operational costs, a large industrial company working together with an electric utility on a venture such as this can make a plant like this a profitable enterprise for both, through the elimination of duplicate services which would be required, and at the same time, one that is beneficial to the public.

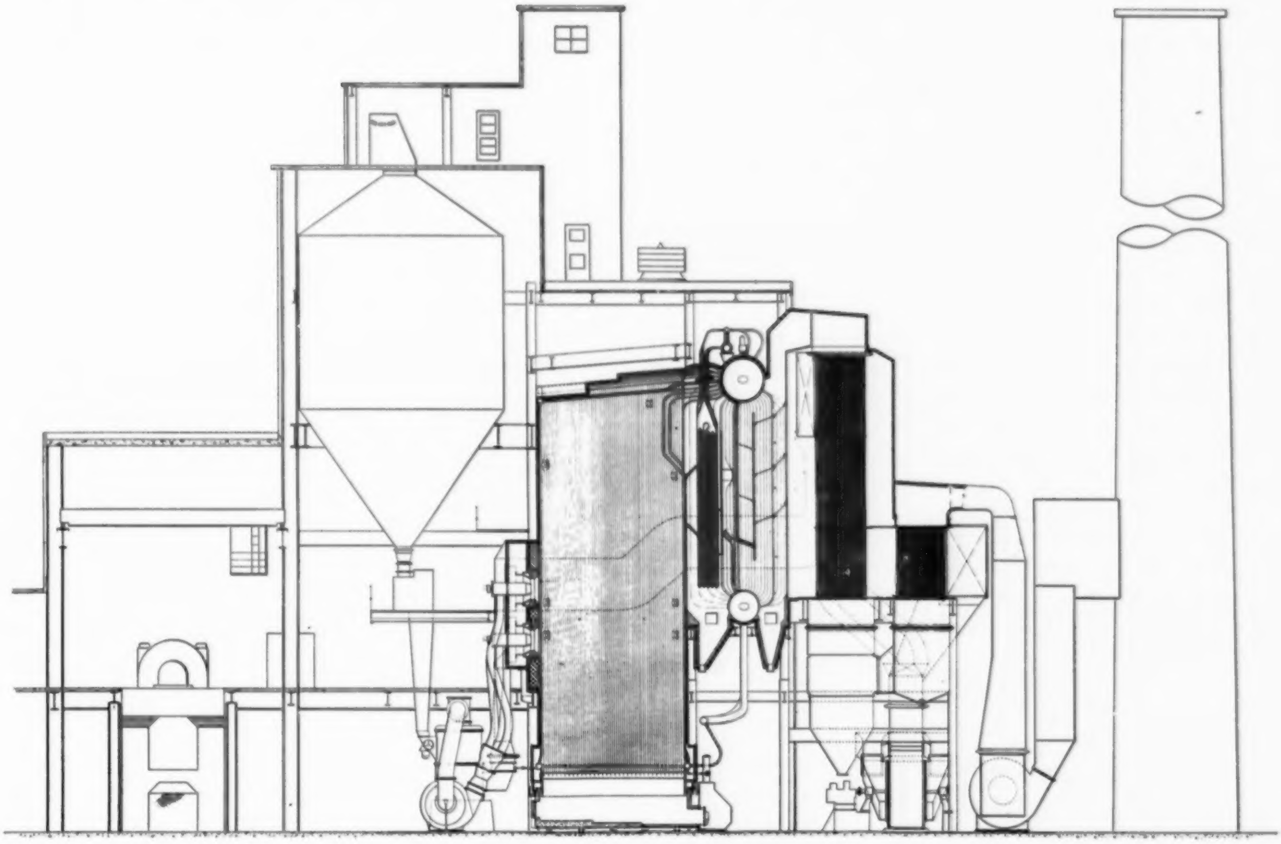
General Plant Description

The Greenwich plant consists of a main building, river-water intake structure, river-water pumphouse and chlorine room, raw-water pumphouse and thawing-pit fuel-oil pumphouse. Yard construction includes three raw-water storage tanks, precipitators, chemical-mixing

[1] At that time Atlantic City Electric was a subsidiary of American Gas and Electric Co. Through a series of corporate changes, ownership of half of the Deepwater plant passed to Philadelphia Electric Co. through its subsidiary, Deepwater Light & Power Co. Atlantic City Electric retained ownership of the other half. In recent years the Atlantic City Electric Co. acquired the assets of the Deepwater Light and Power Co. and is now the sole owner of the Deepwater plant.



Exterior view showing part of the water-treatment system in the foreground



Cross-section through plant

tank, salt-storage hopper and storage tank, condensate-storage tank, light-oil tanks, concentrated-caustic-storage tank, chemical-unloading platform, track hopper for obtaining coal direct from coal cars, coal-crusher tower, coal conveyors, coal-car-thawing pit, switchyard, stack, overhead 2400-v line to river-water pumphouse, railroad spurs, sanitary facilities, fire lines and hydrants, coal-storage area and yard lighting. In order to satisfy the contractual obligations of the Atlantic City Electric Co. to supply the required steam, electrical energy and water to the Repauno Works, the boiler-feed makeup water requirements for this station are approximately 100 per cent. Plant capacity is provided by two boilers, each having a normal steam output of 230,000 lb per hr, with a maximum 4-hr capacity of 255,000 lb per hr at 650 psig, 825 F; one 10,000-kw non-condensing, non-extracting turbo-generator, having a generator nameplate rating of 11,500 kw; two 10,000-gpm river-process-water motor-driven pumps; and a coal-handling system having a capacity of 200 tons per hr, with 4 cylindrical coal bunkers having a capacity of 375 tons each.

The main building houses the two boilers and turbo-generator together with all their necessary auxiliaries, coal bunkers, water-treating equipment, elevators, traveling bridge crane, control room, offices, machine shop, locker room and laboratory. It is supported on a structurally designed reinforced concrete mat, set on wood piles and a steel-framed superstructure with concrete slab and open bar grating levels, precast concrete roof slabs and composition siding (Galbestos) with exterior steel window sash and industrial steel doors.

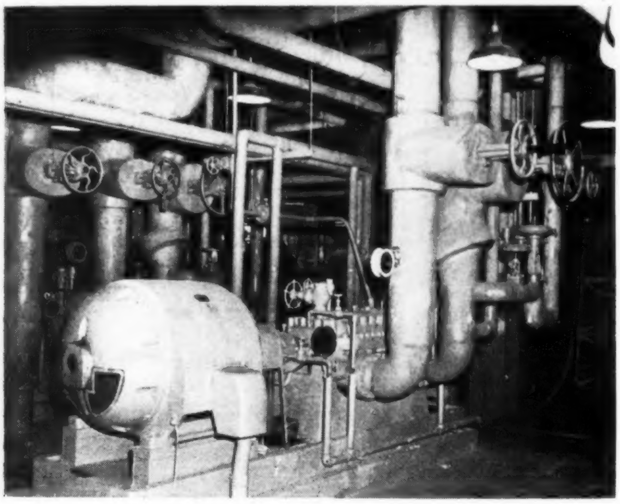
Located east of Thompson's Point Wharf, and extending approximately 660 ft out into the Delaware River is the river-water intake structure. It is constructed of two sheet-steel-piling cylinders filled with rip-rap. Between the two cylinders is an open well formed by sheet-steel piling connecting the north and south tangent points of each cylinder. From the inboard side of the open well, a 60-in.-diam pipe line connects it to the river-water pumphouse on shore. This structure is constructed of a reinforced concrete substructure, steel-framed superstructure with composition siding (Galbestos) and precast concrete roof slab. The pumphouse is divided into three parts namely the pump room itself, an electrical bay housing the 2400-v indoor motor-control switchgear which is fed by the overhead line from the main building, and the chlorine control room which provides and controls the injection of chlorine into the incoming water stream from the Delaware River. This first treatment of the water by chlorination is used primarily for slime control. The chlorinating unit, intermittently operated, is capable of a maximum rate of 2500 lb per day of chlorine and a minimum rate of 500 lb per day, the chlorine solution entering the bottom of the river-water inlet reservoir ahead of the traveling screens. As the water from the intake structure enters the reservoirs beneath the pump room it passes through two vertical-type traveling intake screens for removal of debris, etc. They are capable of screening 12,000 gpm of river water when traveling at 10 ft per min. Adjacent to the screens are two vertical-type, two-stage, bottom-suction, direct-connected, 500-hp motor-driven pumps. These pumps, each of which have a capacity of 10,000 gpm, with a total dynamic head of 160 ft, supply process water to the Repauno Works and raw water to the

storage tanks located at the station and used for further treatment prior to its entry into the boilers.

Boilers and Auxiliaries

The two boilers are of the Combustion Engineering water-tube type, fired by bituminous coal and are readily convertible to burning bunker "C" fuel oil. The superheater outlet conditions are 650 psig, 825 F, with an efficiency of 88 per cent when coal fired at a continuous rating of 230,000 lb per hr.

Each boiler is equipped with two Raymond bowl mills having a nominal capacity of 16,000 lb per hr per mill and complete with a feed control mechanism, fineness regulator and flexible coupling for direct-connected drive. There are four burners per boiler with mechanical oil atomization for bunker "C" fuel oil. They are horizontal firing, and coal or oil may be burned separately or in combination. A counterflow, four-pass air heater of the two-section tubular type is arranged with a short cold end. From a maintenance and operational point of view, this section (which is the last section through which the gas passes) may be replaced, if necessary, without replacing the entire heater. The multiclone-type dust collector when handling 123,100 cfm of gases at 443 F has a collection efficiency of 85.5 per cent, based on fly ash containing not more than 30 per cent under 10 microns in size. It is capable of efficient operation up to and including the peak steam load of 255,000 lb per hr. A Diamond steam soot-blowing system, with air-motor drives, and air-operated controls is provided. An automatic sequential control panel, manually started for each cycle, remotely controls all soot blowers.



Motor-driven boiler feed pump

The forced-draft fans and the induced-draft fans, both turbine driven, are located in the basement. Each F. D. fan is capable of handling up to and including 76,100 cfm at 12.1 in. w.g. and 100 F. Inlet boxes are provided for recirculation of the air at low loads. The induced-draft fans which are of the double-inlet radial-blade-type construction are each capable of handling 121,000 cfm of flue gas at 310 F with a friction loss of 12.8 in. w.g. through the combined boiler, superheater and air heater. Both the I. D. and F. D. turbine drives receive steam at 160 psig and 570 F and exhaust at 35 psig. The turbines are also suitable for operation with 750 F steam during periods when the main turbo-generator is not operating. The combustion control interlocking protection system is so designed that in the event of fan failure the pulverizers are automatically tripped. In order to put the boiler back on the line the I. D. fan must be started first so that complete boiler purging of combustibles is accomplished.

The combustion control system is of the metering type and is capable of automatically controlling boiler combustion over a wide load range. The operator in the control room can quickly change from full automatic to remote manual control of each individual auxiliary and thereby control combustion at any load. A master pressure controller is proved to regulate the load on the boilers in accordance with steam demand. Instruments indicate all important flows, pressures and temperatures of boiler feedwater, steam, air and flue gas and automatically record important data. The load may be divided between the two boilers in any proportion by manual operation of the individual boiler master regulator valves.

Process-steam requirements are supplied from either or both the main turbo-generator exhaust at 170 psig and 570 F and from a main pressure reducing station at 170 psig and approximately 825 F to a steam-atomizing-type desuperheater where condensate spray water is introduced, reducing the steam temperature to a maximum of 390 F. A diaphragm-operated control valve will regulate the quantity of spray water to the desuperheater. The pressure and temperature controls, located in the main control room, will maintain the process-steam temperature to within 3 deg F and the pressure within 1 psi of the design conditions.

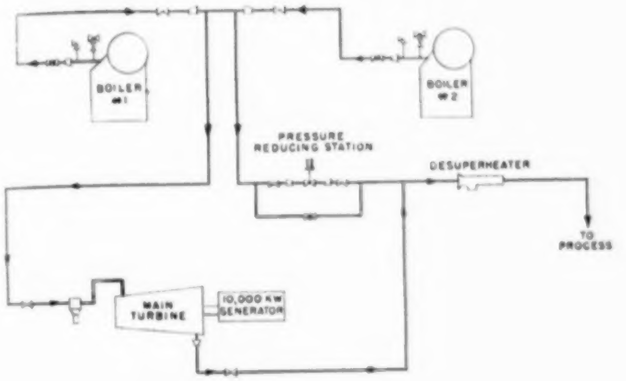
Boiler Feedwater System

From the clearwell the boiler feedwater is pumped by the boiler-feed makeup pumps through a condenser, where it is used as cooling water in the condensate system, and into a vertical spray type deaerator having a delivered capacity of 690,610 lb per hr. The boiler-feed pumps, each capable of delivering 635 gpm of boiler feedwater at 274 F, pump the water from the deaerator through the boiler feedwater regulating valve which maintains the water level at the proper point.

The boiler feedwater air-operated control system is made up of four elements; namely, steam flow from boiler, feedwater flow to the boiler, water level in the boiler drum, and boiler blowdown.

Turbo-Generator and Auxiliaries

The General Electric turbo-generator is a 10,000-kw noncondensing, non-extracting unit, receiving steam at 825 F and 600 psig and exhausting at approximately 175 psig and a temperature of 570 F. The generator is of the enclosed, air-cooled, self-ventilated type and is grounded through the primary winding of a distribution transformer with its secondary winding shunted by a resistor. The generator is further equipped with a 250 v, 50-kw, direct-connected exciter and associated motor-operated field rheostat. The turbine is normally controlled by an exhaust-pressure governor, which opens or closes the turbine throttle valve to maintain the pressure of the exhaust steam going to process. The electric power output will therefore vary in accordance with the process-steam demand up to the point where the maximum gen-



Schematic flow diagram

erator load is reached. Additional steam requirements at this time would decrease the process-steam pressure to the point where the pressure reducing station begins to supply the difference.

In the event of a partial electrical load loss, the turbine, if permitted to remain on back-pressure governing, would overspeed and the resulting trip of the emergency stop valve would shut down the only remaining source of electrical power for the plant. A pre-emergency governor is therefore provided to supersede the back-pressure governor at a predetermined speed below the trip speed.

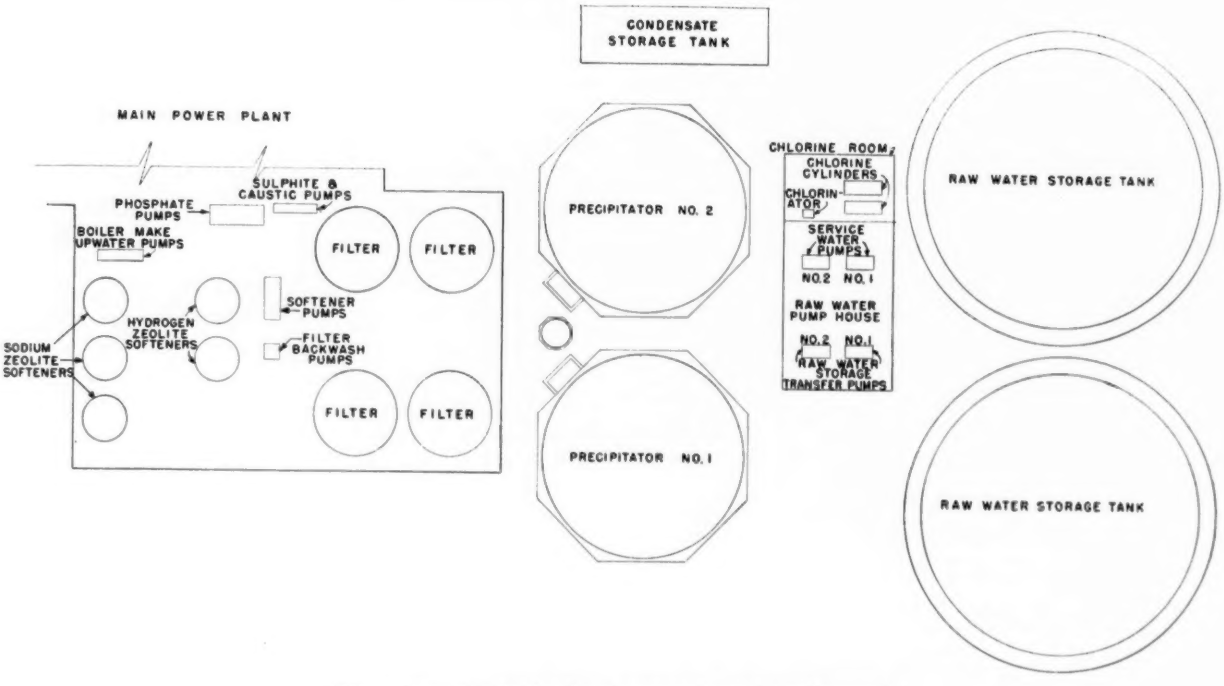
The turbine will continue to operate at the pre-emergency speed until such time as the operator manually reduces the speed to the normal value or until the electrical load is reapplied. If an electrical load, sufficient to bring the turbine down to its normal speed is again applied, the back-pressure governor, automatically, again resumes control. If the turbine throttle pressure drops below a certain predetermined value, an initial pressure regulator supersedes all governors. This regulator closes the throttle and maintains the pressure in the main steam line at the predetermined value. In this way, if one boiler should trip out or cease to supply steam for any reason, the turbine demand would be kept within the capacity of the remaining boiler. If an electrical load in excess of the capacity necessitated by the steam flow is thrown on the generator by a loss of the connection to the Atlantic City Electric Company system, the generator would slow down and motor overload trips would occur throughout the plant. To prevent this the turbine governor will be switched over, automatically, to speed control through solenoid valves tripped by an under-frequency relay before motors trip off on overload. The turbogenerator would then be operated at the required electrical load and the excess steam would be vented to atmosphere, through relief values in the process-steam system, thus maintaining firm electrical power at the plant regardless of process-steam requirements at the Repauno Works. In order to return the turbo-generator to back-pressure control, the solenoid valve must be manually reset.

The turbine-generator is cable-connected, through an outdoor oil circuit breaker, to one half of an outdoor 13,800-v bus with a normally closed bus-sectionalizing loadbreak-disconnecting switch. The other half of the 13,800-v bus will feed a main stepup transformer (rated at 12,000 kva, and of the oil-immersed, self-cooled, three-phase, 34,500–13,800-v type) through an outdoor oil circuit breaker. This 12,000-kva transformer feeds a 34,500-v outgoing line to the Atlantic City Electric Company system through a 34.5-kv outdoor oil circuit breaker. Generator protection against phase-to-phase faults is provided by high-speed current-differential relays with a zone of protection including the generator, the generator cable and the generator breaker. Protection against phase-to-ground faults in the generator, the generator cables and the portion of the switchyard operating at generator voltage is provided by an over-voltage relay across the secondary of the generator neutral grounding transformer. The main stepup transformer is protected by high-speed current-differential relays with a protective zone including the transformer and its associated circuit breakers. Protection of the switchyard 13.8-kv bus is provided by high-speed differential relays.

Water-Treatment Equipment

A thorough investigation for the most efficient and economical means of treating the Delaware River water for boiler water makeup was conducted in conjunction with Sheppard T. Powell and Burns and Roe, Inc. Several schemes were investigated and it was finally decided to treat the water as follows: coagulation, silica reduction, filtration, and hydrogen-sodium-zeolite softeners. Provision is also made for demineralization if at any time the condition of the water should require this treatment. At certain seasons of the year, particularly in the spring and fall, the chloride content of the river water runs as high as 450 ppm. Therefore, the use of river water for boiler makeup is limited to a 7½-hr pumping period per 24 hours, thus requiring the installation of three raw-water storage tanks having a capacity of 630,000 gal each. A second chlorinating unit is installed adjacent to the storage tanks and is similar to the one at the river-water pumphouse except that it operates continuously with a maximum capacity of 200 lb of chlorine per day and a minimum of 20 lb per day. The chlorine solution is used primarily for removal of chemical inhibitors that may interfere with the water-treatment process and is injected into the raw-water transfer-pump discharge line to the water-treatment plant. Provision is made for shot chlorination of the

Exterior view showing arrangement of air heaters, dust collectors and fans



Plan view of principal water-treatment equipment

inlet water to the raw-water storage tanks if a bad summer algae-growth condition warrants it.

The raw water from the storage tanks is pumped to a chemical-mixing tank where a solution of ferric sulfate, a slurry of dolomitic lime and a slurry of magnesium oxide is fed, by gravity, from dry, volumetric-type, chemical feeders. The feeders consist of dissolving chambers, storage hoppers, feeding mechanism and motor-driven mixers to provide homogeneous solutions or slurries in the mixing tanks. The chemically dosed water then enters the precipitators where it is agitated and mixed with previously formed sludge or slurry. It is uniformly delivered to the clarification zone of the tanks where separation is effected by means of the relative motions of the water and sludge. The clear water is drawn off from the top and flows by gravity to filters, having a bed of Anthrafilt and anthracite coal to filter the clarified water. The filters are equipped with rotary surface agitators for surface washing and under drains for backwashing and rinsing.

The water after passing through the filters enters a filtered water clearwell having a capacity of 180,000 gal from which it is pumped to the sodium-zeolite and hydrogen-zeolite softeners. The softened waters combine in a blended assembly to permit admixture, over a wide percentage range, of sodium-zeolite-softened water and hydrogen-zeolite-softened water. The blended soft water flows to a degasifier for removal of free carbon dioxide. The treated, degasified water gravitates to the treated water well, having a capacity of 180,000 gal. Regeneration of the sodium zeolites is accomplished by the admission of a salt solution and the hydrogen zeolites are regenerated by a solution of sulfuric acid. Mounted on a central control board are rate of flow controllers and loss of head gages for each filter; flow recorders, level indicators, alarms, timing devices, etc. for complete control of the water-treatment system. A pH indicator and low and high pH alarms for the treated water are used to determine the proportion of hydrogen- and sodium-softened water for boiler feed. Semiautomatic operation provides that after setting the desired flow rates, timing elements, starting pumps, etc., manually, the system will then operate automatically.

Coal-Handling System

Coal is delivered by coal cars which empty into a 14 × 28-ft double-track hopper which in turn feeds two 36-in. apron feeders, each capable of delivering 100 tons per hr. A 30-in. belt conveyor, traveling at 255 ft per min, carries the coal from the apron feeders under the track hopper, through an inclined tunnel to the top of the crusher house. At this point through a system of chutes and bypasses, the coal is directed to either storage or the crusher. After the coal is crushed an automatic Geary-Jennings sampler and cutter is provided so that samples may be obtained for laboratory analysis. Crushed coal is discharged either onto a 30-in. belt going from the crusher house to the top of the boiler house or to chutes for outside storage. With the above arrangement either crushed or uncrushed coal may be stored in stock piles, with reclaiming effected by bulldozer to the track hopper. A third 30-in. belt, which is loaded by the belt coming from the crusher house, supplies coal through manually operated plows to each of the four 375-ton capacity cylindrical bunkers having a total 60-hr storage capacity.

The flyash, collected by a dry-vacuum-type system from the dust collectors, is mixed with water and is discharged into a separating tank from where it flows by gravity to the ash-disposal hopper which is flooded with water, and into which the dry ash from the boiler is collected. Through a sluiceway, which is provided with a system of spray nozzles, the ash and water mixture is pumped to an ash-disposal area to the north of the plant proper and used as fill.

Instrument air is provided by a compressor (complete with aftercooler, dual controls) which receives and delivers

air at 100 psig for air-operated controls and instruments. Provision is made to reduce the pressure locally at any valve or instrument as required. A compressed air system is also provided for pneumatic-operated tools and equipment and at various outlets for plant maintenance and soot-blower operations.

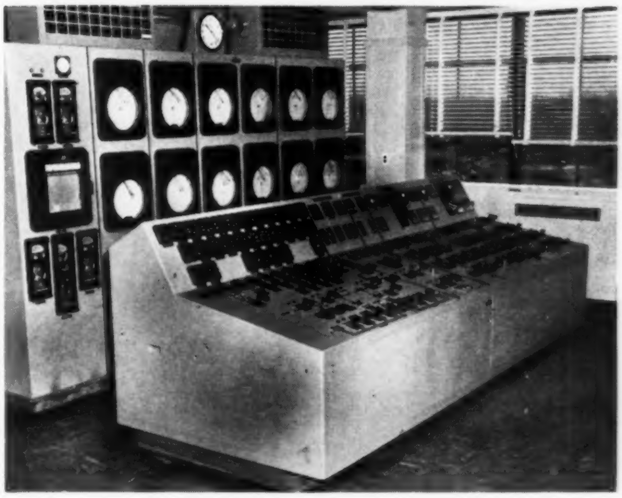
Since there is no condensate return to this plant, it is necessary to make condensate for desuperheating the process steam. Continuous blowdown can run as high as 27 per cent of boiler-inlet feedwater capacity. This blowdown is flashed first at 35 psig and then at 5 psig. The drains from the flash tanks are piped over to the blowdown tank. The 5-psig flashed steam is piped to a shell-and-tube condenser where it is condensed by the makeup feedwater going to the deaerator. The condensate is then piped to a condensate-storage tank. If additional condensate for desuperheating is required, over and above that supplied by the flash tanks, additional steam is reduced from the 35-psig auxiliary-exhaust-steam header.

The chemical-feed system provides for the feeding of disodium phosphate directly to the boiler drums, and caustic soda and sodium sulfite to the boiler-feed-pumps suction header. Caustic soda and sodium sulfite, after dilution, are stored in tanks and are fed to the boiler-feed suction header by continuously operating pumps.

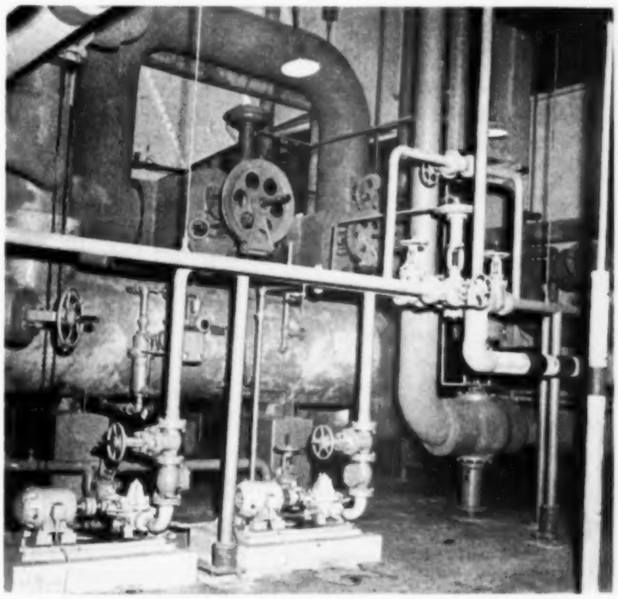
Main Plant Control

A bench-type control board and a vertical, duplex-type instrument and relay board are installed in an air-conditioned control room for the control of turbine-generator unit No. 1, the two boilers, auxiliaries, the process-steam system, pressure-reducing and desuperheating station, and the outdoor switchyard equipment. Circuit-breaker control switches, indicating instruments, selector valves and essential motor-starting-control switches are placed on the bench-type control board.

Mounted in a pit, beneath the benchboard, are various relays. Recording instruments are mounted on the front panel of the duplex-type vertical board with protective relays on the rear panel. An annunciator is also provided in the control room to give visual and audible indication of boiler and turbine-generator equipment operations throughout the station.



Central control panel



A section of the blowdown heat-recovery system

List of Principal Equipment Suppliers

Boilers	Combustion Engineering-Superheater, Inc.
Ash handling	Beaumont Birch Co.
Boiler-feed pumps	Pacific Pumps, Inc.
Coal-handling system	Link-Belt Co.
Deaerator	Elliott Co.
Desuperheater and pressure-reducing station	Swartwout Co.
Elevator	Haughton Elevator Co.
Fabricated piping	W. K. Mitchell & Co., Inc.
Combustion controls and instrumentation	Bailey Meter Co.
Raw-water storage tanks	L. O. Koven Co.
River-water intake pumps	Byron-Jackson Co.
River-water intake structure	Dravo Corp.
Stack	Consolidated Chimney Co.
Starters and motor-control centers	Westinghouse Electric Corp.
Structural steel	Pittsburgh Bridge & Iron Works
Switchgear	Allis-Chalmers Co., I-T-E Circuit Breaker Co.
Transformers	Westinghouse Electric Corp., I-T-E Circuit Breaker Co., General Electric Co.
Traveling water screens	Link-Belt Co.
Turbine-room crane	Northern Engineering Works
Turbo-generator	General Electric Co.
Valves (general)	Crane Co., Edwards Valve Co.
Feedwater treatment equipment	The Permutit Co.
Fans	The Green Economizer Co., Inc.
Precipitator	Western Precipitation Corp.
Soot blowers	Diamond Power Specialty Corp.
Water columns	Yarnall-Waring Co.
Condenser	Whitlock Manufacturing Co.
Flash tanks	Whitlock Manufacturing Co.
Feedwater regulators	Bailey Meter Co.
Air-conditiong unit	Westinghouse Electric Corp.
Auxiliary steam turbines	Elliott Co.
Turbine exhaust relief valve	Atwood & Morrill Co.
Motor-operated feedwater bypass valves	Edwards Valve Co.
Chlorinating equipment	Wallace & Tiernan
Chemical feed system	Proportioneers, Inc.
Pipe hangers and supports	Grinnell Co.
Main control bench and vertical boards	Lexington Electric Co.
Miscellaneous pumps	American Marsh Co., Worthington Pump Co.
Miscellaneous motors	Allis-Chalmers Mfg. Co., Louis Allis Co.
Scales	Richardson Scale Co.
Insulation	Armstrong Cork Co.

The 1953 American Power Conference

A Brief Digest of Some of the More Important Papers

THE Fifteenth Annual Meeting of the American Power Conference (prior to 1952 the Midwest Power Conference) which was held at the Hotel Sherman, Chicago, March 25–27, fully lived up to its reputation, in quality of papers and attendance, as the foremost forum in this country on current power practice. As in former years, it was sponsored by the Illinois Institute of Technology with the cooperation of twelve universities and the local sections of a number of engineering societies; also, for the first time, by the national bodies of the ASME and the AIEE.

At the opening session on Wednesday morning **Charles Y. Freeman,** chairman of the Commonwealth Edison executive committee, delivered the address of welcome and was followed by **Dean W. A. Lewis** of the Illinois Institute of Technology Graduate School, who reviewed the aims and history of the Conference. **W. A. Roberts,** president of Allis-Chalmers Mfg. Co., then gave a talk which he termed "Electric Power for Good Living."

The public, said Mr. Roberts, has failed to give full credit to those who make electricity available at low cost to the consumer. The annual increase in capacity of central stations now equals the total installed capacity at the end of World War I. Since electric power has made for much greater industrial production at greatly reduced hours of work, it has lifted drudgery and contributed not only to higher standards of living but also to an increased life span. Population of the United States is increasing at the rate of 50,000 per week, which continually broadens the market for electric power.

H. P. Liversidge, chairman of the board of the Philadelphia Electric Company, speaking at the Wednesday luncheon, devoted his address to the current shortage of engineers, as shown by the advertisements in the Sunday papers. The central station industry, he pointed out, has only lately become concerned over such a shortage, and many industries are still indifferent. The initial step in relieving the situation is better understanding on the part of the public. Colleges must be prepared to cope with increased enrollment. In this connection he cited and recommended the five-year cooperative plan now in force at some technical schools whereby the students' time is alternately spent in the plant or shops and in the classroom. Expense thus incurred by the plants should be a direct charge against doing business. Although the number of technically trained engineers has increased tenfold since 1900, statistics for 1950 showed an average of only one engineer to 65 workmen in industry.

Electric Industry in Perspective

Addressing the luncheon on Thursday, **B. L. England,** president of the Edison Electric Institute, pointed out some aspects of the electric utility industry's past and future. In the decade between the close of the war and 1955, the electric industry will have more than doubled its 1945 generating capacity and generation should be more than twice the 222 billion kilowatt-hours of that year.

This growth he attributed largely to the traditional idea of giving service in which the human values are emphasized. He added:

"We who have the task of guiding today's electric progress toward tomorrow have a particular responsibility toward those who will have to be ready to lead in the future. We must help their capabilities to grow and mature; and to do this effectively, we must make sure that they have a widening field in which to work, and get the feel of leadership."

Experience with Large Generating Units

Availability of large turbine-generators, comparable to that of smaller units, as well as excellent maintenance records has been the experience of the Philadelphia Electric Company, according to a paper by **R. P. Liversidge,** vice president of that company.

Since 1935, a 165,000-kw 400-psig, 850-F, 1800-rpm tandem-compound unit has been operating at the Richmond Station and three 182,000-kw machines, installed in 1947 and 1948, are in service—two of the cross-compound type at Southwark Station and one of the tandem-compound type at Richmond. Also, the company now has on order a 200,000-kw single-shaft 3600-rpm 1800-psig-1000/1000 F reheat unit scheduled for operation in 1955.

In explanation of justification for the number of large units on a system the size of that of the Philadelphia Electric Company, the author mentioned the extensive inter-connections with the Pennsylvania Power & Light Company and the Public Service Electric & Gas Company of New Jersey through a 220-kw transmission ring. The average availability of the four large units, covering a total of 23 turbine-years has been 93.6 per cent.

The maintenance record of the 165,000-kw unit was such that not until 1949—fourteen years after initial operation—was the high-pressure end opened for inspection, at which time both the rotating and stationary blades were found to be in good condition, although work was necessary on the casing. The maintenance cost on this machine has been 40 per cent under the average for all machines on the system and that on the 182,000-kw machines at Southwark 75 per cent less than the system average.

The importance of careful maintenance planning is shown by the following outage figures:

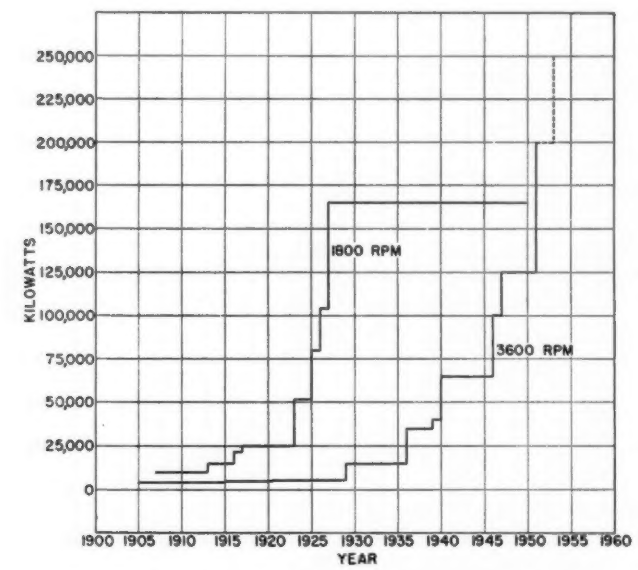
Richmond No. 9	182,000 kw......	$8500 per day
Southwark Nos. 1 & 2	182,000 kw......	$7000 per day
Richmond No. 12	165,000 kw......	$4400 per day
Delaware No. 8	125,000 kw......	$8100 per day

Mr. Liversidge commented further that at times it becomes necessary, for economical operation, to shut down some of the Company's large units; but, following the technique developed by Consolidated Edison Company of New York for quick starts, the 182,000-kw Southwark machines can be started in twenty minutes after an eight-hour or less shutdown.

Turbine Development

"Development of the 3600-rpm Turbine" was the subject of a paper by **H. R. Reese** of the Westinghouse Electric Corp. Noting that over the past fifty years steam conditions have increased at a steady annual rate of 43 psi and 13 deg F, he pointed out that design problems at current elevated conditions are increasing at an exponential rate many times the steady rate. Also because the incremental thermodynamic gain is decreasing with higher steam pressures and temperatures, it is becoming more difficult to justify the increased costs for design at these conditions. However, the 3600-rpm turbine has made the design problem less severe and has reduced the unit cost.

Ratings for 1800-rpm units increased rapidly during the 1920's, reaching a peak of 165,000 kw in 1928 which appears to be the practical capability point for these units. The 3600-rpm ratings increased slowly until 1946, but in the intervening years they have jumped from 65,000 to 200,000 kw. (The foregoing are ratings, not capability kw, which would be 250,000 kw for the 100,000-kw rating.)



Progress in kilowatt rating of single-shaft turbine-generators

In looking ahead for a ten-year period the author anticipated the following developments:

1. If austenitic materials are available, initial steam conditions will continue to increase but at a slower rate. By 1963 a few turbines should be operating at 3000 psig, 1200 F.
2. The 3600-rpm single-shaft turbine-generator will continue to grow and will probably exceed 300,000 kw. It is not unreasonable to expect nearly all future units to be single-shaft 3600-rpm machines.
3. With higher steam conditions and increased ratings it will be easier to justify the double reheat cycle, and a few of the large units are expected to operate with this cycle.
4. At very higher pressures and temperatures some portions of the turbine may be designed as expendable parts, such as the first-stage element, which is subjected to the most severe service.

Construction Materials for 3600-rpm Turbines

Inlet Temperature	Composition and Type of Material
451–825 F	Ferritic carbon steel Carbon—0.30 per cent
826–900 F	Ferritic low chrome Carbon—0.30 per cent Molybdenum—0.50 per cent Chromium—0.50 per cent
901–950 F	Ferritic medium chrome Carbon—0.20 per cent Molybdenum—0.50 per cent Chromium—1.25 per cent
951–1000 F	Ferritic high chrome Carbon—0.20 per cent Molybdenum—1.00 per cent Chromium—2.25 per cent
1001–1100 F	Austenitic steel Carbon—0.08 per cent Molybdenum—2.50 per cent Chromium—18.00 per cent Nickel—8.00 per cent Columbium—1.00 per cent

Design and Application of Large Steam Turbines

According to **Carl Schabtach** of General Electric Company, the design and application of large turbines are influenced broadly by relationships between interest rates and prices of fuel, labor and materials, and by the size and rate of growth of utility systems, to the end that efficiency, reliability, price and size are balanced to minimize the cost of power generated over the useful life of the machines. Recently, the combination of these factors has generally justified purchase of the most efficient units obtainable with the requisite reliability, and as large as warranted by the size and interconnection of the power systems served. The result has been the construction of many plants for operation at 1000–1050 F and 1450, 1800 or 2000 psig; and in most cases with reheat.

In general, he said, large units are more economical than smaller ones; they can be made more efficient, cost less and require fewer operators per kilowatt. Units considerably larger than any thus far undertaken are likely to be ordered during the next few years.

Relative station costs, adjusted for efficiency and capacity at 1800 psig, 1000/1000 F and 1 in. Hg are shown in the following tabulation:

Type	TC-3600 rpm	CC-3600/1800 rpm
Total station input, million Btu/Hr	1,758	1,758
Gross output, kw	200,000	204,412
Station auxiliary power, kw	12,000	12,000
Net station output, kw	188,000	192,412
Station heat rate, Btu/kwh	9,353	9,139
Relative Station Costs		
Base station cost	$28,300,000	$28,300,000
Turb.-gen. price	Base	+430,000
Foundation of mat. and building	Base	+119,000
Miscellaneous	Base	+ 60,000
Capitalized fuel saving	Base	−164,100*
Total adjusted station cost	$28,300,000	$28,744,900
Total station cost/kw	$150.53	$149.39

* Based on fuel at $.20/million Btu, 60% load factor, 15% capitalization ratio, and the difference in efficiency at 60% of capacity.

Progress on the electrical end of large steam turbine-generators was outlined in a companion paper by **C. E. Kilbourne** and **J. B. McClure** of General Electric Company, which included the following tabulation of those from 125,000 kva and up installed and under construction by that company, together with the actual or anticipated year of initial operation.

Kva	Number in Service	1st Service Year	Number on Order	Total
21,500,000 Kva in Large 3600 Rpm Generators (Max. Kva Capability at 30 Psi Hydrogen Press)				
125,000	18	1947	37	55
140,000	12	1950	7	19
160,000	5	1951	15	20
180,000	0	1953	22	22
220,000	0	1953	22	22
260,000	0	1955	1	1
	35		104	139
7,000,000 Kva in Large 1800 Rpm Generators (Max. Kva Capability at 30 Psi* Hydrogen Press)				
125,000	11	1940	8	19
140,000	11	1944	0	11
156,250	7	1949	1	8
175,000	1	1953	4	5
220,000	3	1937	0	3
245,000	1	1952	0	1
	34		13	47

* Not all are arranged for or operated at 30 psi. There are also two record breaking air cooled generators, each of 200,000 kva rating which have been in service since 1932.

The rotors of large generators are now generally made of solid alloy steel forgings, the alloying elements being principally nickel with some chromium, molybdenum and occasionally vanadium, and elaborate heat treatment. For improvement of magnetic properties careful control of carbon and chromium content was found to be essential.

Cold-worked, silver-bearing copper conductors are employed for rotor windings instead of soft annealed copper, as formerly used.

Since lighter weight rotor end-windings permit larger diameter rotors and as the capacity varies about as the cube of the rotor diameter, the ability to build larger diameter rotors directly affects the maximum size of machine. Some years ago aluminum was tried for rotor windings and while this resulted in improvement in retaining-ring stress the full advantage could not be exploited because of the losses, as aluminum has only two-thirds the conductivity of copper. However, its conductivity-weight ratio is still superior to copper. Extensive research to improve the physical properties of aluminum led to an alloyed aluminum, designated as "conductor aluminum" which is now being used. But this necessitates a larger rotor diameter than copper windings and this, in turn, increases the armature's outside structure, which for very large machines would be beyond railroad limits for a one-piece armature, and necessitate a structure that could be disassembled for shipment.

Cross Compound Designs

Speaking on the cross-compound steam turbine for large capacity installations, **Charles D. Wilson** of Allis-Chalmers Mfg. Company stated that while the 3600-rpm, tandem-compound machine in general costs less and requires less foundation, it cannot have as large a steam-leaving area as the cross-compound type which thereby can operate at a higher vacuum and show higher efficiency. Moreover, the cross-compound can be built in large sizes yet employ components of conservative design.

The trend in cross-compound units is toward employment of high-temperature elements on the high-pressure, 3600-rpm shaft which delivers up to two-thirds of the total power, depending upon the pressure. Studies for the new Oak Creek Station of the Wisconsin Electric Power Company resulted in a decision to employ a 120,000-kw, cross-compound unit having two 3600-rpm, high-pressure elements of 80,000 kw combined rating and a 40,000-kw, 1800-rpm, low-pressure element, all mounted on a common foundation. The steam conditions in this case are 1600–1800 psig, 1000 F initial and 1000 F reheat temperatures.

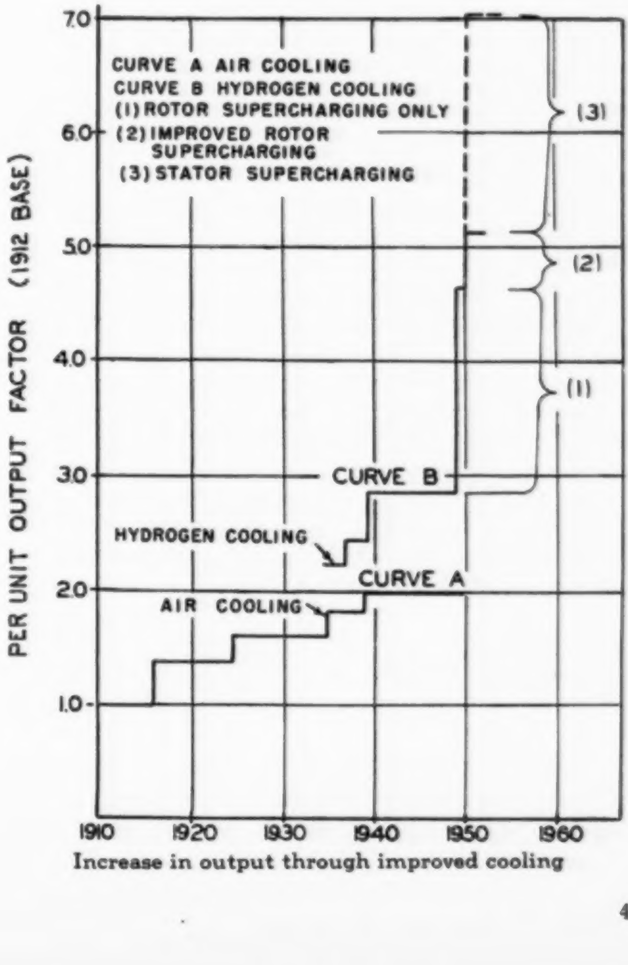
Discussion

The discussion following these papers brought out the fact that one utility and several equipment manufacturers are making studies for topping a midwestern station with a 4500-psig, 1200-F unit employing two stages of reheat.

Another matter that was brought out in the discussion was the recommendation of some turbine builders that for reheat operation a stop valve be installed ahead of the intercept valve.

Turbine-Generator Cooling

In a paper entitled "Present Status of Supercharged Cooling," **W. L. Ringland** and **L. T. Rosenberg** of Allis-Chalmers Manufacturing Co. traced the history of improvements for ventilating large generators. Supercharged cooling, first introduced in 1951, permits the con-



Increase in output through improved cooling

struction of 3600-rpm single-shaft generators of greater capacity than before, without the need for reduced short-circuit ratio. Machines of greater capacity can be factory assembled, and required space for generators in the power station may be reduced.

The supercharged generator has a two-stage compressor mounted on one end similar to an aircraft supercharger. Developing several times the maximum fan pressure previously used in this type of machine, the compressor forces the hydrogen at high velocity along ducts in the rotor copper. Because of this high pressure and the resulting high gas velocity, heat is removed more effectively; also, the machine remains relatively cool at its overload ratings. The compressor has no wearing parts, is of heavy plate steel construction, and is said to require no attention. Bearings and seals are smaller, requiring less oil and maintenance, while the quantity of hydrogen required to fill the machine is greatly reduced.

With partial supercharging, rotor and stator coil lengths are reduced about 40 per cent, and it is expected that use of complete supercharging at 30 psig will permit another 30 per cent shortening of coils. Because of internal cooling of the conductors, the iron temperature is very nearly equal to that of the copper. Differential expansion and compressive stresses are also reduced because of this absence of temperature drop through the insulation. End-to-end stator supercharging will benefit from less thermal expansion because of a far lower coil temperature below the observed hot spot.

One of the supercharged generators has been in operation since 1951 and had a 100 per cent availability record in 1952. The authors reported that an experimental unit is now under construction which will incorporate a number of features, in addition to supercharging, which are intended to help reduce losses and facilitate assembly, shipment, installation and maintenance.

Inner-Cooled Turbine-Generators

J. W. Batchelor of Westinghouse Electric Corp., in a paper under the above title, stated that inner-cooled design provides a means for eliminating the temperature drops through the insulation and the steel of the rotor and stator windings by providing a path for the gas through the coils themselves. In the rotor winding, ducts are formed in the copper straps with provision for the gas to enter these ducts at the end and be discharged at the center of the rotor. There is a slight difference in construction of the stator winding, but the effect is essentially the same.

The difference between a 125,000-kw generator cooled in the conventional manner and an inner-cooled generator having matched turbine capability is shown as follows in terms of savings for the latter:

Total weight	142,000 lb—24 per cent
Total generator weight	160,000 lb—28 per cent
Heaviest piece	126,000 lb—31 per cent
Rotor	49,000 lb—47 per cent

This type of construction is being used on 10 units ranging in size from 80,000 to 250,000 kw at 30 psig. The units have a combined equivalent rating of 1,618,000 kw.

Experience with Reheat

In line with the widespread acceptance of the reheat cycle, operating experience with approximately three million kilowatts of capability, placed in commercial service since August 1949, was reported by **Otto de Lorenzi**, educational director of Combustion Engineering, Inc.

The paper also listed 221 reheat units, aggregating over twenty-seven million kilowatts capacity, in sizes from 40,000 to 250,000 kw, ordered, under construction or in operation from January 1, 1946, to January 1953. Of these, 105 units were ordered since March 1, 1951. Moreover, use of larger units has increased with the unqualified acceptance of reheat. Operating pressures range from 1250 to 2300 psig and primary steam temperatures from 950 to 1100 F.

With one or two exceptions, the units reported were of similar design, involving tangential firing with tilting burners, two-stage superheater with the reheater located between the superheater banks. Reheat temperature is maintained at constant level through the normal operating range by burner tilt and excess temperature of primary steam is corrected by spray-water injection.

With regard to the differences in heat requirements of the superheater and the reheater, Mr. de Lorenzi pointed out that, inasmuch as the superheater is supplied with saturated steam, the amount of heat added per pound at all loads remains the same for constant temperature at the outlet header. However, feedwater temperature will vary with turbine output and thus change the ratio of total heat input to the unit to gas flow over the superheater per pound of steam generated. Hence, to maintain constant steam temperature, it becomes necessary to vary the gas temperature at the superheater inlet.

Conditions for reheater operation, however, are quite different because temperature and pressure of steam at the high-pressure turbine exhaust decreases with a reduction in output. Therefore, the heat added to produce constant temperature at the reheater outlet header must be increasingly greater as output falls off.

Thus for constant steam temperature from both superheater and reheater, gas temperature at the furnace outlet should simultaneously have a falling as well as a rising characteristic with decrease in capacity. But since these conditions are impossible to obtain with a single furnace, the surfaces are proportioned so as to require the same furnace temperature at maximum output. Also, the high- and low-temperature banks of the primary superheater are designed to minimize differences in gas temperature requirements at partial loads.

With this arrangement steam temperature at the reheater outlet is used to regulate furnace temperature by tilting the burners, and steam temperature at the superheater outlet is used to meter the amount of spray water needed for interstage desuperheating. The desuperheater installed at the reheater inlet is merely a safety device for use only during abnormal operating periods.

Specific data and operating charts were shown for Russell Station of the Rochester Gas and Electric Corp., the Dunkirk Station of the Niagara Mohawk Power Co., and Danskammer Point Station of the Central Hudson Gas & Electric Co. Availability records of nine reheat units in operation in 1950 and 1951 ranged from 93.69 to 98.63 per cent.

Plant personnel reported that they found the reheat units to be no more temperamental or difficult to handle than conventional units. Moreover, use of the controlled circulation principle does not alter any actual steam-generating characteristics except to provide for assured and uniform distribution of water to saturated steam surfaces of the unit.

Trends in Combustion and Steam Temperature Control

In reviewing this subject **P. S. Dickey,** vice president of Bailey Meter Co. listed the following as the principal functions of a suitable automatic control system for regulating a modern high-capacity, high-pressure and high-temperature steam generating unit:

1. Supply the correct amount of fuel and air to the furnace so as to release heat in accordance with steam demand.
2. Water fed to the boiler in accordance with steam demand.
3. Avoidance of controllable losses due to excess air or incomplete combustion by proper fuel-air proportioning.
4. Distribution of heat released in furnace to evaporating and superheating surfaces so as to produce the required quantity of steam at the desired pressure and temperature.
5. Arrangement for instrumentation and control equipment for most efficient operation.

For any boiler furnace or fuel-burning system proper proportioning of the air and fuel is essential. With air in excess of proper requirements fuel is wasted. In other words, for each ten per cent of air in excess of requirements the loss will average about one per cent of the total fuel burned. Furthermore, there is still greater loss when less than the required amount of air is supplied.

While the fuel-air ratio varies with the heating value of the coal, the Btu released per pound of air properly burned with coal is nearly constant. Carefully conducted combustion tests are necessary to establish the correct steam flow-air flow relationship. Factors that may influence this relationship are variations in feed temperature and cleanliness of the heating surfaces.

When burning fuel oil or gas it is usually possible to measure the fuel accurately and to proportion the air supply accordingly. So long as the Btu per pound of fuel is constant the fuel flow-air flow ratio meter is a reliable combustion guide. However, when burning mixed gases or oil and gas it is necessary to totalize the fuels on a Btu or air requirement basis. When burning oil or gas with coal, difficulties may be encountered in measuring the weight-rate flow of the coal, and also because of the varying air requirements of the different fuels. In such cases the steam flow-air flow method is generally employed, supplemented with a gas analyzer.

There has been a revival of interest in the use of combustion gas analysis to proportion the fuel and air.

With reference to the prevention of furnace explosions, Mr. Dickey cited the work of Associated Factory Mutual Fire Insurance Companies in the proper application of a combustibles analyzer to gas- and oil-fired furnaces.

Centralized control, he observed, although involving some increase in the number of remote controls and instruments, as well as in protective devices, nevertheless results in improved utilization of operating manpower which far outweighs the additional cost or complication.

Prevention of Metal Deposits

Metal pickup in the pre-boiler cycle from moisture condensation in the turbine, as well as from the condenser, heaters, pumps and economizer has long been recognized. In the past, efforts to correct it were directed at the prevention of dissolved oxygen and increasing the pH of the feedwater by recirculating boiler water back to the feedwater. With the maintenance of lower alkalinities in the boiler water and increase in operating pressures the required amount of recirculating water increased, control became more difficult, and heat losses were higher. Also, phosphate deposits formed in the feed lines. With more effective means of removing dissolved oxygen available, recirculation of boiler water was discontinued. However, accompanying greater purity of makeup water and steam there was noticeable pickup of metal in the pre-boiler cycle.

A paper by **F. L. Archibald** and **J. W. Purssell, Jr.,** of Boston Edison Co. and **Prof. F. G. Straub** of the University of Illinois entitled "Prevention of Metal Losses in the Wet Steam Areas of Steam Turbines" related experiences with sulfur dioxide, hydrogen sulfide, carbon dioxide, ammonia and organic amines on the metal pickup in the cycle.

Tests were conducted at several large steam electric generating stations wherein the addition of ammonia caused the iron content to be decreased until a minimum value was reached with a pH of 9.

Incidentally, in most cases no increase in copper pickup was noted, although in one case mentioned it was found that the addition of ammonia, while reducing the iron pickup in the feedwater was apparently not reducing the metal loss in the wet steam areas of the turbine. It was suggested that the metal loss in this region might have been the result of corrosion-erosion by the water.

A program of investigation in 1952 at the Mystic Station to study the effects of various chemicals on iron pickup indicated ammonia treatment, without sulfite, to be the best as concerned pickup and maintenance of a high pH in the 18th stage of the turbine; although this meant loss of protection of the oxygen-reducing agent in the boiler water.

Therefore, attention was directed toward use of hydrazine (N_2H_4) as a reducing agent. This was found to aid in maintaining a higher pH. It has a high vapor pressure at boiler temperature which allows it to vaporize with the steam. Hydrazine may break down to form ammonia, and metals such as copper and nickel may act as catalysts in the reactions.

Further tests were conducted using morpholine instead of ammonia which showed that under these conditions sulfite treatment of the boiler water could be maintained. The morpholine was added as a 20 per cent solution in water to a 50-gal dilution tank where it was diluted with condensate, this diluted solution being pumped continuously to the deaerator storage tanks to maintain a pH of 8.8 to 9 in the feedwater and condensate.

Industrial Power Plant Operation

A group of papers, sponsored by the NAPE dealt with problems encountered in the operation of different types of industrial and institutional power plants.

The paper mill industry is one that requires large quantities of both process steam and electricity. According to **Wyle Austin,** of Marathon Corp., it comprises 762 paper mills and 255 pulp mills of various capacities throughout the United States. Because of the heavy demands for low-pressure steam such plants usually can economically produce all or part of the electrical requirements, providing a substantial balance can be maintained between its steam and power demands. As drying pressures and electrical demands increased, higher steam pressures and temperatures became necessary and, as an alternate to installing new higher pressure boilers and turbines, some mills turned to purchased power; although at present the average paper mill generates steam at two or three pressures, produces part of its power with back-pressure or extraction turbines and purchases the balance of its electrical requirements.

The power engineer in the paper industry, said Mr. Austin, should have a complete knowledge of all the processes; he should assume responsibility for checking steam and power usage; and initiate changes or recommend such new equipment in the mill as will improve heat balance or alleviate steam or power shortage. Full cooperation between the power plant and mill managements should be encouraged.

Since the average mill requires large quantities of heated water, all such heating should be done with exhaust steam; and, wherever possible, indirect heaters should be applied to save condensate. Furthermore, for every ton of paper dried about 40 tons of air must be heated to room temperature. This requires attention to machine exhaust and mill ventilation as ventilating fans consume sizable amounts of power.

Feedwater treatment is another most important item, as feedwater problems in the paper industry are generally more involved than in the average industrial plant.

Operating pressures for equipment now being installed in the paper industry range from 400 to 800 psig and 750 F total steam temperature. The boilers usually range from 75,000 to 150,000 lb per hr, are usually equipped with economizers and spreader-stoker fired. Turbines range from 2500 to 10,000 kw and are either straight back-pressure machines, with or without extraction, or condensing units with one or two extraction points.

Another industry that uses large quantities of process steam and hot water is that of the packing house. Discussing the problems involved, **L. E. Joslin** of the Krey Packing Co. considered a workable and efficient heat balance to be the primary consideration; also, that particular emphasis should be placed on the accuracy of power plant records, such as fuel burned, steam supplied to various services, occurrence of peak and minimum production, quantites of hot water supplied, electrical and refrigeration output, etc. He observed, however, that all too often the operating engineer, who is responsible for results and must bear the blame for poor operation and low efficiency, is not consulted when decisions are made.

To illustrate the many design and operating problems involved, Mr. Joslin cited, as typical, the steps that had to be gone through in his own plant when selecting equipment to replace purchased power, increase refrigeration capacity and improve the overall efficiency.

C. R. Bender, chief engineer of the St. Louis State Hospital, reviewed a number of operating problems encountered in running an outmoded institutional power plant. However, through improved firing methods, better use of exhaust steam, the repair of leaks and changing to cheaper coal, it was possible to lower the fuel bill from $110,000 in 1949 to $67,000 for the year 1952.

One of the problems in such an institutional power plant, Mr. Bender pointed out, is that of obtaining equipment and supplies because of the red tape involved; also it is difficult to obtain and keep qualified operating personnel.

The fourth paper at this session dealt with a penal institution and was prepared by **Sal Gran,** chief engineer of the California State Prison at San Quentin. After reviewing the set-up in such an institution covering the occupational assignments of prisoners, their vocational training and the necessity for maintaining constant checks as a safety measure, he cited the numerous services provided by the prison boiler plant including steam for general heating, that for the prison laundry, the kitchen, the prison hospital and numerous prison manufacturing industries which employ over 500 men.

The main boiler house contains five units generating approximately a million pounds of steam per day at 125 psig and is located inside the prison walls. Except for two free stationary engineers, it is operated by prisoners, most of whom have to be trained. There are ten men assigned to the boiler house, but the average time of such an assigment is only six months, due to transfers, paroles, etc.

It is the duty of the free personnel at all times to carefully control all tools, ropes and ladders.

Feedwater Conditioning by Evaporation

This was the title of a paper by **A. M. Impagliazzo** of The Griscom-Russell Co. who declared that in analyzing two dissimilar processes, such as evaporation and demineralization, it is difficult to determine true comparative costs because the conditions under which reasonably close equivalence is achieved are not well established. He added that it is inevitable that the relative importance attached to the various factors by one investigator will be questioned by another whose experience or reasoning has led him to a different conclusion. The author therefore limited his remarks to a presentation of quantitative cost data for evaporators and to a discussion of those questions which the user must answer in making comparisons in individual cases.

Three empirical equations were presented to show the extra steam flow required at the throttle to maintain power output when using single-effect evaporators, with and without separate condensers, and two-effect evaporators without separate condensers. Other empirical

equations were included to show installed cost of evaporators and space requirements.

In summarizing, Mr. Impagliazzo stated that makeup with total dissolved solids not to exceed 1 ppm can be produced by evaporation, with quality relatively unaffected by time or normal variations in raw water analysis. Single-effect evaporators without separate condensers are most commonly used, but studies indicate that the use of separate condensers with the evaporator located in a lower pressure section of the cycle results in appreciable savings. Two-effect evaporators resulted in the highest annual cost for the 60,000-kw unit which served as the basis of the study, but they may be justified because, under certain conditions, they can be operated as double-effect equipment for normal requirements at maximum fuel economy and as single-effect for extra capacity. The author also mentioned that the fuel economy of compression-type plants is not as good as that of evaporators but that its capacity is not tied in with turbine output, and that it may be operated at maximum load during off-peak power periods.

Evaporation Vs. Demineralization

In a paper entitled "Economics, the Key to Evaporation Vs. Demineralization for Makeup in High-Pressure Steam Power Plants," **E. B. Morris** and **C. E. Brune** of the American Gas & Electric Service Corp. attempted to clarify and define the basic economic factors and to show their relative importance by employing a specific case as an example. Their discussions were based upon the following two basic premises:

1. The effluent of a demineralizer and the vapor from an evaporator are of equal purity or the difference is so slight that no significant effect on makeup requirements due to boiler blowdown is evident.
2. Single-bed or two-bed demineralization is to be employed without the complication of modified arrangements that may be desirable with certain waters to achieve desired results.

The example chosen is based upon a plant comprising five 200,000-kw units operating at 2000 psig and 1050/-1050 F reheat. Customary design would provide six evaporators (one spare) to furnish a total makeup capacity of 2.5 per cent at full load operation, with an associated water-treating plant having 2.8 per cent makeup capacity to provide for evaporator blowdown and other miscellaneous uses. Alternately, similar requirements for coagulation and filtration would apply for demineralization with a total available output equivalent to 2.5 per cent makeup. Demineralizing equipment would be sized so that with a unit out of service for maintenance, the remaining net capacity would provide a minimum of 1.5 per cent makeup for full load operation. In making their economic analysis, the authors took into consideration fixed investment charges, required makeup and its effect on cycle heat rate and on kilowatt capacity, and actual costs of evaporated and demineralized makeup. Based upon the specific case in question, they reached the following conclusions:

1. In this case, the total investment for an evaporator installation is $120,000 larger than for a demineralizer.
2. Fuel is the significant cost factor for evaporation and varies proportionally with heat degradation and makeup produced. On the other hand, chemical costs are the important factor with demineralization and vary not only in direct proportion to makeup produced but also with total ion concentrations of raw waters. The latter factor may be subject to even greater variation than that of fuel costs for different plants and locations.
3. Total annual costs for the 0.85 per cent makeup condition indicate a small advantage for demineralization, although it is so slight that intangibles might sway the decision. For 2.5 per cent makeup, the total cost economics distinctly favors evaporation.
4. The difference in investment charges may be compensated for by differences in the reverse direction of the other factors for the 0.85 per cent and 1.5 per cent makeup examples. For 2.5 per cent makeup the other factors dominate.

In concluding, the authors stated that demineralization may be favored in other instances by higher heat-rate differentials, higher fuel costs, lower makeup quantities and raw waters of lower total solids. On the other hand, high fuel costs also favor an evaporator condenser, the installation of which goes a long way toward eliminating heat-rate differentials in favor of demineralization.

Regeneration of Cation Exchange

In a paper entitled "Acid Regeneration of Cation Exchangers," **F. K. Lindsay** of The National Aluminate Corp. presented data to show the importance of application techniques in the use of both sulfuric and hydrochloric acids as regenerants for cation-exchange resins. Factors largely responsible for the choice of acid are comparative costs for particular installations and availability of the acid under consideration. For the most part sulfuric acid is used in large installations because it is more economic. On the other hand, hydrochloric acid may have advantages because of its ease of application and higher exchange capacities, particularly in smaller installations.

It is believed that sulfuric acid regeneration is most effectively carried out by using a "step-wise regenerant addition" in which the regenerant concentration and/or regenerant flow are varied. By selecting the proper technique the dosage can be reduced to a minimum consistent with exchange capacity and effluent quality. Optimum results are generally obtained when the highest possible acid concentration contacts the resin bed at the slowest possible flow rate without incurring calcium sulfate precipitation.

Experience with Amines

H. J. Guillory, superintendent of production of the Central Louisiana Electric Co. reported on his company's experience with amines at the Coughlin Station, a low-makeup outdoor steam plant containing four gas-fired steam generating units, three of which operate at 600 psig, 825 F and one at 850 psig, 900 F. The makeup, which is approximately one per cent, is obtained from two evaporators discharging their vapor to deaerating heaters. Initially, feed for these evaporators was obtained from deep wells with no provision for softening or pretreatment of the well water. However they were treated internally with phosphate, a lignin organic and

sodium sulfite; the phosphate being intended for iron stabilization.

While it was necessary only to clean one evaporator after five years' service, analysis of the deep-well water showed high free CO_2, and steam samples run through a Straub degasifier revealed 3 to 3.5 ppm CO_2 despite what was considered excellent deaeration facilities. Furthermore, the iron content in the system showed a gradual increase.

Therefore, it was decided to treat the evaporator feed with an acid-regenerated zeolite, followed by degasification and neutralization with caustic soda. Such a unit was placed in service in 1951.

This resulted in reduction of the CO_2 to 1.5 ppm and a decrease in conductivity of the condensate at the hotwell to 0.6 micromhos. Nevertheless, a small but definite residual of CO_2 at the hotwell still remained. Iron in the deaerator discharge dropped from 0.5–1.0 ppm to 0.3–0.4 ppm whereas that in the boiler dropped from 6 or 7 ppm to a stabilized value of 3–4 ppm. Only occasional traces of ammonia were found in the condensate after the pre-treatment of the evaporator feed and pH of the condensate at the deaerator discharge ranged from 6.6 to 7.

While no serious corrosion problems were encountered some such difficulty was experienced with heater drains. Moreover, it was believed possible to reduce still further the corrosive tendencies in the water cycle and also the iron content.

Accordingly, after considering various other treatments, it was decided to employ amines to rid the system of the remaining CO_2 and to institute a reliable means of pH control. Resort was had to a morpholine type of amine in 1952. After about three months operation the iron was reduced to 0.1 ppm or less, and the ammonia to 0.025 ppm with a pH of 7.

The Materials Situation

J. F. Moore, of Ebasco Services, Inc., who has been closely associated with the work of the government in allocating materials for the heavy industries, discussed this subject as regards the power industry. This industry, he said, consumes 3 per cent of the steel produced, 17 per cent of the copper and about 11 per cent of the aluminum. Of the steel used some 12 per cent goes into structural work, about 40 per cent into pressure tubing, 12 per cent into light plate and considerable into heavy plates, in addition to that which goes into forgings, castings, etc.

The central station load increase during each of the years 1946–1948 was approximately 11 per cent, but in 1949 it slipped back to 5 per cent then started to rise suddenly and was 11 per cent again in 1952. It is estimated that this annual increase will hold for the next three years and that some 26 million kilowatts will be added to the demand. Of this about $4^1/_2$ million will be due to Atomic Energy Commission demands.

At the end of 1952 average reserve capacity of the utility industry was 10.2, despite shortages of power in some sections of the country. It has been estimated that in the next two years a reserve of 12.5 to 13 per cent will be needed to cover unforeseen increases in load. Present plans call for 16 per cent by 1955, but it is doubtful if the materials situation will be able to meet this.

Last year some 9 million kilowatts of new capacity was scheduled for service, but only 6 million was added. This was less than that of 1951, due to the materials situation. This year's schedule calls for the addition of 12 million kilowatts and the next three years' $34^1/_2$ million, which would, if attained, provide a 17 per cent reserve.

However, in Mr. Moore's opinion, it will be possible to add only 9 million in 1953 and 10 million in 1954, and the winter of 1953–1954 may be worse than last winter. It is anticipated that the supply will have caught up by 1956. This situation, which is due to insufficient flow of material for heavy power equipment (not field construction), was brought about by a combination of defense demands and the steel strike which will long be felt.

Equipment manufacturers are not receiving their requirements of special steels. While the second half of this year is expected to show improvement in this respect it will not reach normal until 1954 or 1955. In an unforeseen emergency the lack of adequate reserves would be felt keenly.

Federal Power Practices

E. R. de Luccia, vice president of Pacific Power & Light Co. and formerly chief of the Bureau of Power of the Federal Power Commission, attempted to answer the question posed by the subject of his paper, "Are Federal Power Practices Sound National Policy?" He noted that over the past twenty years a pattern of practices has been created by Federal agencies which are entrusted with the construction and disposal of power emanating from programs for developing and conserving water resources. Continuance of these practices brings up the question of their effect upon our national strength, and therefore it may be asked whether they constitute sound policy.

The most important Federal laws and statutes relating to the construction of facilities for the generation of electrical power and for its disposal and marketing include the Reclamation Acts of 1906 and 1939, the Federal Water Power Act of 1920, the Boulder Canyon Act of 1928, the Federal Power Act of 1935, the Tennessee Valley Authority Act of 1933, the Bonneville Act of 1937, and the Flood Control Acts of 1938, 1944 and 1945. There are two principal Federal electric power marketing agencies, the Department of Interior and the Tennessee Valley Authority, the power practices of which determine Federal power policies and responsibilities. Another important factor in relation to these agencies is the Federal Power Commission, which does not construct nor market electric power but which has significance in terms of its reactions to the practices and assertions of the other Federal electric power marketing agencies. Mr. de Luccia cited several examples of the practices of Federal agencies, including the Roanoke River case, the question of disposal of power from the Clark Hill Hydroelectric Project on the Savannah River, cases dealing with the allocation of power costs in multiple-purpose projects, and a power policy directive issued by the Secretary of the Interior early in 1946. The essence of the last-mentioned directive is to prohibit firm power contracts between Federal agencies and private power companies.

The speaker emphasized that the private utility industry, as a part of our economy, is a proved asset performing without cost to Federal, state or local governments, except in the matter of regulation, that it furnishes tax revenue for all government levels, and that it creates wealth by voluntary participation of free capital. He urged that the policies of the past twenty years should be understood in terms of the magnitude of the responsibility which may be thrust upon Congress by administrative power practices. On the basis of the report of the President's Material Policy Commission, required installed capacity by 1975 will be 279,000,000 kw. Should the Federal govenment assume the responsibility to supply all electric power to meet this estimated requirement, Congress would be required to appropriate an estimated $2,500,000,000 annually to build needed generating capacity and transmission lines.

In concluding, Mr. de Luccia made it clear that he believed that any Federal participation in developing water resources should have regard for the welfare of all the people and should be on a partnership basis with participation of people and agencies in the project areas.

Nuclear Power

A timely and authoritative symposium, under the chairmansip of **Louis C. McCabe** of the U. S. Bureau of Mines, was held on Wednesday evening with participants from the Atomic Energy Commission, the Argonne National Laboratory, the utilities, the Congressional Joint Committee on Atomic Energy and the legal profession. The scope of the papers included the Atomic Energy Commission's appraisal of atomic power, engineering and technical problems involved, an economic evaluation, current legislation and proposed changes in the Atomic Energy Act.

The first paper, scheduled to be presented by Gordon E. Dean, chairman of the Commission was delivered in his absence by **W. L. Davidson,** a member of the Commission Staff. This covered arguments both against and for civilian use of nuclear power.

On the negative side it pointed out that since there are now adequate reserves of relatively low cost fuels in the United States, with fuel cost representing only a fraction of the total cost of providing electricity and present prospects of very cheap nuclear power under 25 years remote, it is difficult to argue for early development of nuclear power for civilian use on an economic basis. Also, the question might be raised as to possible lessening of security through a widespread nuclear power development program, if preferential treatment be avoided through broad declassification of reactor technology or granting numerous clearances to industrial personnel. And finally, such a program would cost many millions of dollars.

On the positive side of this question, the speaker mentioned the importance of the United States preserving leadership in every phase of atomic energy development if the American public is willing to back up this desire with its dollars. Secondly, although no technical advance is now apparent that will provide civilian nuclear power at a price significantly cheaper than that from conventional fuels, no one can guarantee this to be inevitably the case. On the other hand, it is possible that advances in the military reactor program may lead to economic civilian nuclear power before 25 years have elapsed. Great Britain, Canada, France, Holland, Norway, Sweden and Belgium all have reactor programs under way, but little is known of Russia and her satellites.

Finally, looking to the time when our military nuclear stockpile attains its desired size, it would appear prudent to develop useful outlets for the nuclear fuel then available or which could utilize our expanded plant capacity.

Engineering and Technical Problems

This phase of the subject was discussed by **Walter H. Zinn,** director of the Argonne National Laboratory, Chicago, who prefaced his remarks by the statement: "We will know what it takes to make an economically competitive nuclear power plant only after we have gained experience in operating the first reactor which is designed and constructed specifically as a central station power plant." He added that four or five years would probably be required to design, engineer and construct such a plant after a decision had been made.

Although the cost of uranium as mined is $3.50 per pound this figure would have to be multipled by ten to put it in a form suitable for use in a reactor. Moreover, most of this is in the form of U^{238} of which only 0.7 of one per cent is fissionable as U^{235}. Complete separation, such as is necessary for military use, is extremely costly. However, by allowing some of the neutrons released in the fission to be captured by the U^{238}, fissionable plutonium is created and the probable fuel cost might be held down close to one mill per kilowatt-hour. Indications are that the domestic supply would be sufficient to get an infant nuclear-fueled power industry going.

Of the moderating materials investigated, heavy water and beryllium have shown superiority but both are costly and have low availability. Graphite has been in use and ordinary water has possibilities because of its availability and cheapness. As a moderator the water would need to be insulated from the high temperature or pressurized. Zirconium has qualities superior to magnesium, aluminum or stainless steel because of corrosion susceptibility and relatively low melting points. As a reactor coolant, helium rates best with heavy water, bismuth-lead, sodium and regular water following in order. The Hanford reactors are water-cooled, as is also the Argonne submarine reactor whereas the G. E. designed submarine reactor is sodium-cooled.

Mr. Zinn concluded with the observation that since the United States has led the world in atomic energy development for military weapons and has large resources of technically trained manpower in this line it would not make sense to pass up the additional effort and expense required to realize the major peaceful use of nuclear energy.

Atomic-Generated Electric Power

Under the title of "Economic Evaluation of the Industrial Use of Atomic Energy," **Walker L. Cisler,** president of The Detroit Edison Co., stated that it is possible to evaluate the economics of atomic energy only in broad terms. There is much still to be known concerning the technical problems of recovering the heat energy result-

ing from nuclear fission and applying it to useful industrial purposes. In addition to the costly and complex facilities required for research, security restrictions believed necessary for national safety add further complications.

Practical application of atomic energy has been the subject of widely varying estimates, but five to ten years seems to be the one most commonly accepted. Even though this is accomplished, only a small number of installations providing a limited amount of electric power needs can be brought into service within that period.

In regard to the possible successful development of the fast-breeder principle for nuclear reactors, Mr. Cisler observed that the resources of fissionable materials would be supplemented to assure what he termed "adequate heat energy resources of fantastic proportions." In accomplishing the actual competitive use of atomic fuels, the economic value of plutonium and other radioactive materials is expected to be a most important item. Plutonium should have a market either as a weapons material, as a fuel for transportation, or as the initial charge for other reactors.

Mr. Cisler expressed the belief that costs of reactors for electric-power generation can be brought within reason and that an important new segment of industry may result. However, for atomic energy to become a truly important economic factor, participation of private industry and the use of private capital for new plants and production facilities are needed. Modification of the Atomic Energy Act is also necessary to permit ownership of fissionable materials and facilities for using those materials under conditions compatible with national security.

Changes in Atomic Energy Act Suggested

O. M. Ruebhausen, representing the New York Bar Association, called for a revised definition of restricted information that would apply only to atomic weapons, changes in the Atomic Energy Act that would permit private industry both to produce and possess fissionable material, and to permit private patent protection where it does not affect defense. To this end he suggested that the President appoint a review commission to make recommendations covering new legislation.

Speaking for the Congressional Joint Committee on Atomic Energy, its chairman, Representative **Carl Hinshaw,** observed that, aside from this committee, Congress is not giving much thought to nuclear energy. The provisions of the present law are very positive and permit industry to make studies which can be passed on to the AEC for evaluation. If the latter sees fit a report may be made to the President who, in turn, can report to Congress.

Although vast progess has been made in the field of military weapons, it has taken the Navy and the AEC since 1940 to work out designs for a prototype submarine power plant which, despite a cost of 300 million dollars, has not yet materialized.

An aircraft propulsion program involving ten companies was closed out after three years and a new project in this line has been started. The expenditure, said Mr. Hinshaw, dwarfs the Navy project.

It appears that a unique relation exists between the Commission and the Joint Congressional Committee. The latter has access to the secrets but is not free to act; it is, in effect, a defender of the AEC whose actions, Mr. Hinshaw charged, are sometimes tinged with bureaucracy. He called for Congress to set a new policy.

Gas Turbine Combustors

Herbert R. Hazard of Battelle Memorial Institute had as the subject of a paper "Some Practical Aspects of Combustion in the Gas Turbine." Actually, combustors are direct-fired air heaters having extremely high heat-release rates (by comparison with boiler standards). In several commercial machines combustor inlet temperatures range from 275 F at idling to 500 F at full load, with outlet temperatures up to 1475 F. In operation the fuel rate is increased approximately in proportion to the air weight, as fuel-air ratios do not vary greatly over the load range except during acceleration or deceleration. Combustion pressures vary from 15 psig at idling to about 75 psig at full load in simple units and may range up to 120 psig in more complex units.

There are a number of practical requirements for successful combustor operation. Stability of combustion over a wide range of fuel-air ratios is necessary to avoid loss of ignition during load changes. Moderate metal temperatures are necessary to insure reasonably long life of the combustor liner, and steep temperature gradients in the liner must be avoided to prevent warping. Positive light-off is essential to avoid explosions resulting from delayed ignition.

Speaking of the future, Mr. Hazard indicated that ceramic coatings to protect the metal surface against corrosion at high operating temperatures appear promising. Likewise, improvement in the design of combustion equipment can be expected to result in longer life through improved cooling, reduction of steep temperature gradients in liner material and lower stress levels. Although selected grades of fuel oil can now be burned in gas-turbine combustors, much development effort is now being expended on the problem of making it possible to burn all grades indiscriminately.

With respect to the commercial introduction of open-cycle gas turbines for coal firing, the author felt that several years would have to elapse before this would be feasible. In concluding, he called attention to the role of fundamental research in combustion processes and expressed the hope that practical analytical design methods may be developed, based upon a more thorough understanding of the processes involved.

Superheater Tube Temperature Measurements*

Problems encountered in making accurate tube-temperature measurements are discussed. Five types of thermocouples suitable for measurements inside and outside the combustion chamber are described, emphasis being placed upon those having long life. Switching units suitable for use with as many as 160 measuring points are mentioned.

By T. W. JENKINS, Jr.

Leeds & Northrup Company, Philadelphia, Pa.

THE primary value of superheater tube-temperature measurements is the knowledge gained of temperature distribution across the boiler. This information serves as a check on circulation through the tubes so that safe metal temperature will not be exceeded. Measurements may be taken by thermocouples installed on individual tubes near the superheater outlet header. These measurements not only assist in determining and testing the design of the unit and the proper location of soot blowers but are also important operating guides in the use of blower equipment and in determining the most suitable method of firing to maintain proper temperature distribution across the boiler.

Additional benefits may be obtained from these measurements. During start-up, tube temperatures indicate when water in pendant-type superheater or reheater tubes has boiled out. There has been at least one instance where tube-temperature measurements have indicated a flow restriction in one of the tubes. On some boiler designs, tube-temperature measurements indicate excessive carry-over of water from the drums or excessive moisture introduced in desuperheating.

When this type of measurement was first attempted, the measuring equipment was not designed to be permanent. The results obtained were useful in design studies and in determining start-up procedures. Since the life of the measuring equipment was short, the measurements could not be used as an operating guide. One of the earliest comprehensive studies made on superheater tube-temperature measurements was in 1932, reported in a paper by Arthur Williams of The Superheater Company, presented at the 1932 ASME Annual Meeting.

It has long been recognized that a tube-temperature measurement is not an easy measurement to make accurately, for the metal temperature of the tube may be appreciably less than that of the surrounding hot gases. One of the simplest methods of obtaining this measurement is to attach a thermocouple to the outside of the superheater tube. The thermocouple leads must be carried through the high-temperature zone to the outside. Thus, these thermocouple leads will be at a higher temperature than the superheater tube and will tend to conduct heat to the superheater tube at the point where the measurement is made. This conduction will distort the temperature measurement, causing an error known as a conduction error.

The best means of reducing this error to a minimum is to bring the thermocouple leads away from the point of measurement at the superheater tube in a manner so that the temperature of the wires will approach the tube temperature, thus minimizing the conduction error. In early installations, the thermocouple wires were attached to the tube by means of peening. The tube was drilled to a depth of $^1/_{16}$ in. and at a diameter slightly larger than the thermocouple wire. Two holes were made approximately $^1/_8$ to $^1/_4$ in. apart, one for each thermocouple wire. The thermocouple wires were then inserted in the holes and peened in, and the wires were wrapped around the tube for several turns in a manner to provide good thermal contact with the tube. Thus the temperature of the leads in the vicinity of the measuring junction was brought close to the temperature of the tubes, thereby minimizing the conduction error. Of course, it was necessary to insulate electrically these thermocouple wires from the tube. Mica was frequently used as insulating material, along with glass-covered wire of approximately 18, 20, or 22 gage to further minimize conduction errors.

This general method of making the tube-temperature measurement was used in a number of installations for obtaining test data. Because of the small size of wire to minimize conduction errors, the thermocouple element had a fairly short life.

Tests for Further Protection

C. G. R. Humphreys of Combustion Engineering Company, in an article published in the December 1944 issue of COMBUSTION, reported results of tests indicating that further protection could be applied to the thermocouple leads. Thin steel cover plates were installed over the thermocouple leads at the measuring junction to provide this protection. Since they were welded to the superheater tube, they provided good thermal contact between the cover plate and the tube, thus maintaining the temperature of the plate and of the lead wire at essentially the same temperature as the tube, thereby minimizing conduction errors.

At the present time, many boilers are designed so that the temperature measurement of tubes entering the superheater or reheater outlet header may be made outside the combustion chamber of the furnace in the roof vestible, or "doghouse," or the chamber between the fur-

* Presented at Instrument Society of America Winter Conference, Hotel Statler, New York, N. Y., February 18, 1953.

nace roof and boiler casing. In this general type of application, the temperature of the surrounding atmosphere approaches that of the tubes. In addition the atmosphere is relatively still, thus minimizing conditions tending to cause conduction errors. However, measurements are frequently made on elements actually within the combustion chamber, particularly on reheater tubes, to insure that safe temperatures exist during startup.

These measurements on tubes within the combustion chamber present the greatest problems. It is apparent that the measurements must be carefully made to minimize thermocouple-conduction errors which will be caused by the flow of the hot products of combustion past the thermocouple leads. In addition, for a reasonable length of life of the thermocouple element, the thermocouple must be protected from contamination by hot gases which might result in a calibration shift and ultimate failure. A reducing atmosphere will contaminate chromel and alumel thermocouple wires, reducing the emf output of the thermocouple for a given temperature measurement, and crystallize the metal causing ultimate failure. High sulfur content in the gases also contaminates the couple.

If measurements are only for test purposes of short duration, protection need not be provided. However, it has been found desirable on many units recently installed or currently being designed to provide tube-temperature measuring equipment which can be used during operation of the boiler and which, therefore, must have long life.

Protecting Thermocouples

The only satisfactory means of protecting the thermocouples from the hot products of combustion is to seal the couple from these gases. Not only must the couple be protected within the combustion chamber, but also in the chamber between the furnace roof and boiler casing, if there is any possibility that products of combustion may enter this section, as might be expected on a positive-pressure boiler.

If the tube-temperature measurements at the reheater outlet or superheater outlet are made in a section of the roof vestibule in which no products of combustion will be present, protection from the atmosphere is not necessary and unprotected couples may be used. Fig. 1 illustrates one method of attaching a suitable couple to a tube where unprotected couples will be satisfactory. The thermocouple is made up of 14-gage chromel and alumel thermocouple wire in 2-hole porcelain insulators 1 in. long. Note that the measuring junction is welded in a flattened section of steel tubing, which, in turn, is welded to the superheater tube. The welding insures good thermal contact between the thermocouple and the tube. To minimize conduction errors, it is good practice to tie the couple to the tube with asbestos tape reinforced with iron wire or nichrome wire for 12 to 18 in. from the measuring junction. It is assumed that the atmosphere will consist of reasonably still air and that the air temperature will approach that of the tubes, thus making further precautions to minimize conduction errors unnecessary. Mechanical support of the thermocouples is required. Fourteen-gage couples are used as a compromise between the small size to minimize conduction errors and a large size to provide satisfactory mechanical strength. The thermocouples may be supported individually or a number of couples may be placed in a supporting channel or tray and brought through the boiler casing to suitable terminals.

Twenty-gage glass-insulated wire has been used for this type of installation. Where temperatures will exceed 1000 F, the glass-insulated 20-gage wire will not have as long a life expectancy as the thermocouple illustrated in Fig. 1. Chromel–alumel thermocouples are preferred for this application over iron-constantan couples. For a given wire size, the former couples can withstand a higher temperature than the latter. In general for 14-gage protected couples, the maximum temperature for chromel-alumel is 2000 F, and for iron-constantan is only 1100 F. For a 14-gage unprotected couple, the maximum for chromel-alumel couples is 1700 F and for iron-constantan couples, approximately 900 F.

Fig. 2 illustrates one method of making a measurement when products of combustion are present in the atmosphere. The thermocouple without the protection tube is basically the same as that illustrated in Fig. 1. However, protection has been added to seal out the products of combustion. Note that the protection tube has been ground off on one side and welded to the superheater (or reheater) tube. This provides good thermal contact, thus bringing the protection tube temperature and thermocouple lead temperature close to the superheater tube temperature, which minimizes the conduction error. The mass of the protection tube is relatively small so that the temperature of the superheater tube is not appreciably changed by the addition of this couple. The protection tube is $^3/_8$-in. 18-8 stainless steel pipe where it is exposed to the flow of the hot products of combustion. However, in the roof vestibule or "doghouse," the tem-

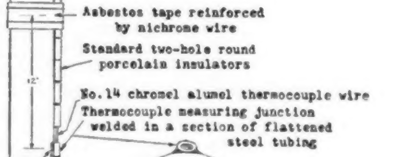


Fig. 1—Superheater tube located outside combustion chamber

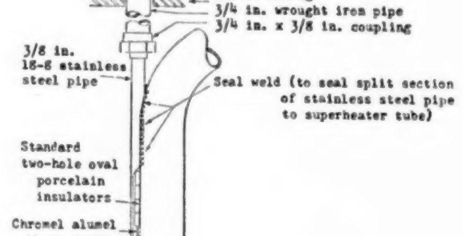


Fig. 2—Superheater tube located in combustion chamber

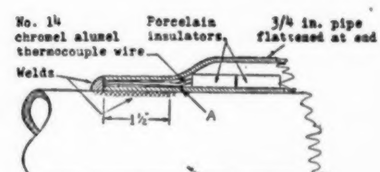


Fig. 3—Superheater tube thermocouple (pipe flattened at end)

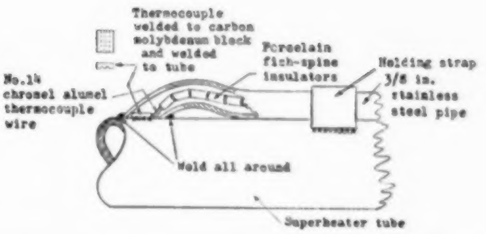


Fig. 4—Superheater tube thermocouple (pipe bowed behind thermocouple)

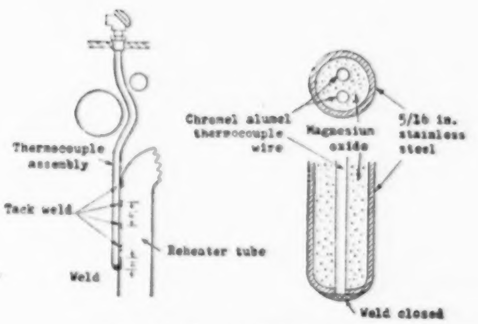


Fig. 5—Swaged-type thermocouple

perature is considerably lower and $^3/_4$-in. wrought iron pipe is suitable. The basic purpose of the protection tube is to protect the thermocouple from contamination by the hot products of combustion. This protection will be no better than the seal provided by the seal weld.

Figs. 3 and 4 illustrate alternate methods which have been used to make this measurement. Each of these two methods enables the use of a simpler weld to seal out the hot products of combustion. However, each has the limitation that it does not provide as good thermal contact between the protection tube and the superheater tube element as the arrangement shown in Fig. 2. It is expected that the conduction errors will be greater. Most of the heat picked up from the hot gases by the thermocouple protection tube is conducted to the superheater element in the vicinity of the measuring junction of the thermocouple thus raising the temperature at this point.

Factors Influencing Errors

The conduction errors cannot be accurately estimated and may or may not be appreciable. Some of the factors influencing the magnitude of this error include the following:

1. The temperature difference between the hot products of combustion and superheater element.
2. The mass of the protection tube relative to that of the superheater element.
3. The rate of heat transfer from the hot gases to the thermocouple protection tube.
4. The velocity of the hot gases.
5. The velocity of the steam flow through the superheater element.

In the face of the unknown, with so many variables, it is felt that steps which can be readily taken to minimize the conduction errors are justified.

One or the major limitations of this type of measuring element is the difficulty or impossibility of replacing the element. This limitation does not apply to the unprotected thermocouples illustrated in Fig. 1. Of course, where replacement presents a problem, the obvious answer is to design the thermocouple and its installation so that reasonable life of the thermocouple may be expected and replacement becomes unnecessary.

Some attempts have been made to design a thermocouple for this application which might be easier to replace. In each case, either some sacrifice has been made by reducing the protection and shortening the life of the couple or by increasing the possibility of conduction errors. The mass of the thermocouple and its protection tube at the location of the measuring junction must be kept reasonably small to minimize conduction errors, and should be in closest possible thermal contact with the superheater tube. Proper protection and proper installation will eliminate the need for replacement.

In this connection, some experience has been obtained indicating that proper installation will provide satisfactory life. In one installation made two years ago, approximately 5 per cent of the thermocouples failed in the first few months of use. Since that time, however, there have been no additional failures. This can indicate that the early failures were caused by improper protection, and those thermocouples adequately protected have not failed. The thermocouple installations were generally of the type illustrated in Fig. 1 and in Fig. 4.

Somewhat similar results were reported in another installation, where the percentage of early failures was near 20 per cent. Here, the thermocouples were generally similar to those shown in Fig. 2 except that the couples were peened to the superheater tubes and alundum cement was used to seal the thermocouple at each end of the protection tube. An inadequate seal would result in an early failure whereas a satisfactory seal would result in an indefinite life. Since all the failures occurred early in their use, it is expected that failures resulted from an inadequate seal. It is felt that a real seal will furnish indefinite protection.

Swaged-Type Thermocouple

Fig. 5 illustrates a swaged-type thermocouple. The particular assembly illustrated, consists of a chromel-alumel thermocouple encased in magnesium oxide enclosed in a $^5/_{16}$-in. O.D., type 309 stainless-steel sheath. The measuring junction is welded to the closed end of the sheath. This swaged-type construction, which is similar to that employed in the electric heating elements of domestic electric stoves, provides a thermocouple element that is sufficiently flexible so that it may be bent around obstructions. It should be noted that the element is welded to the superheater tube for a distance of approximately 2 in. from the measuring junction and tack welded at approximately 6-in. intervals along the rest of the superheater tube where the thermocouple element is maintained in close proximity with the tube to prevent overheating from the hot gases. The field welding has no bearing on the efficiency of the seal of the thermocouple against the effects of the hot products of

combustion. Thus, the technique of the field welding should not affect thermocouple life.

It is expected that the installation cost of such a thermocouple element will be considerably less than for a thermocouple of the type illustrated in Fig. 2. This cost reduction would be made possible in view of the following:

1. The element is sufficiently flexible to facilitate bending in the field to clear obstructions in the roof vestibule or "doghouse."
2. Less engineering and drafting time will be required to detail the construction and design of the thermocouple to clear obstructions.
3. The field welding costs may be somewhat less.
4. Grinding the protection tube to the contour of the superheater element is eliminated.
5. Since the efficiency of the protection is independent of field welding, a higher percentage of permanent couples is expected.
6. These thermocouples may be provided with a compression-type fitting to facilitate their exit through the boiler casing. On positive-pressure units, this will provide an effective pressure seal.
7. In view of the relative flexibility, it may be possible to group a number of elements to go through the boiler casing at one location.

These advantages may be gained with no sacrifice in the basic function of the thermocouple to measuring temperature accurately. Conduction errors are expected to be as low or lower than the arrangements previously shown. Sealing at the factory against the hot products of combustion will insure longest possible life for the thermocouple.

Protection from High Temperature

Swaged-type thermocouples can be provided in diameters larger and smaller than $^5/_{16}$-in. O.D. However, this size is felt to be a reasonable compromise considering conduction errors, flexibility and long life. The thermocouple assembly should be protected from the high temperatures of the products of combustion by maintaining reasonably close contact between the thermocouple assembly and the superheater element in the combustion zone. It is estimated that approximately 1500 F will be the maximum temperature which this couple can withstand with a reasonable length of life. This maximum temperature would depend upon the size of element used. It is felt that, as with other type elements, some slack or allowance should be made for expansion between supports of the couple.

To obtain maximum benefit from tube-temperature measurements and to provide a complete picture of temperature distribution, a large number of measurements are required. Accordingly, a measuring instrument must be designed to accommodate a large number of primary elements. A multi-point, multi-bank type scanner assembly consists of an indicator and recorder assembly, and a switch unit with indicating lights to identify the thermocouple measurement currently being made.

The switching unit is normally arranged in banks or groups, of twenty thermocouples, with as many as eight banks being handled by one switching unit. One signal light indicates the particular bank on which measurements are being made, and other signal lights indicate the particular element within that bank on which the measurement is being made. This switching unit also includes switches to permit complete banks to be cut into service or out of service as selected. In addition, switches are provided to permit any one thermocouple to be manually selected and continuously measured when desired.

Makeup of Typical Installation

The typical installation includes a number of alarms, frequently one alarm associated with each bank of twenty thermocouples. In this typical installation, whenever any one point exceeds its alarm setting, not only is the alarm actuated, but the recorder will automatically start recording. The record starts with a measurement of the point which actuated the alarm and all successive points until the recorder is manually stopped.

The standard speed of operation is four seconds per point. Faster speeds are available when required, and instruments have been provided with a faster speed. The maximum number of points which can be accommodated by a single switching unit is 160 points (eight banks of twenty points each). Many instruments have been provided with less than eight banks as required by the particular installation. In addition, there have been some installations where more than one switching unit has been used, thus providing coverage for more than 160 points. Instruments have been furnished with as high as 840 points being scanned.

It is usual to find a particular bank or banks devoted to measurements of tube temperatures at the superheater outlet, with other banks devoted to measurements on reheater tubes within the combustion chamber of the furnace. Frequently, a bank has been used for measurements of miscellaneous drum temperatures, and other temperatures particularly useful during start-up, but not necessarily used in routine operation. Thus, this particular bank of measurements might be cut out during normal operation permitting the remaining points to be scanned more frequently.

Creep in Steels for Steam Power Plants

A paper by **A. M. Sage** on "Steels for Steam Power Plants," at the March 13, 1953, General Meeting of the Institution of Mechanical Engineers, reviewed work carried out by a committee of the British Electrical and Allied Industries Research Association over the last twenty years. This included studies of the effects of creep properties in different steels leading to the adoption of chromium-molybdenum and chromium-molybdenum-silicon, and, to a lesser extent, molybdenum-vanadium steel for superheater tubes and headers, as well as for piping employing temperatures above 900 F. From creep tests the stress-time relation for each component was obtained. A summary of the first few years' work of the Committee was published in 1939 and the present summary takes through 1952.

In the early work carried out to provide design data for carbon steels, attempts were made to correlate certain determinable properties with long-time creep behavior. These tests at a temperature of 842 F showed that good creep properties were more consistently obtained with acid open-hearth steels than with basic open-hearth steels, although there was considerable resistance to creep for these steels as the length of test increased. This indicated the danger of assessing long-time creep behavior from short-time tests.

Creep curves for carbon–0.5 per cent molybdenum steels at about 1080 F, and at lower stresses, showed a tendency for an increase in the creep resistance to occur after a period of 3000 to 5000 hr, according to the stress and temperature conditions. However, it was observed that the carbon–0.5 per cent molybdenum steel specimens, under some conditions of stress and temperature, failed with relatively small extensions. The following data were obtained on stress in pounds per square inch to produce 0.1 and 0.5 per cent creep in 10^5 hours, as obtained by extrapolation from 1000 to 5000 hr:

Deg F	Superheater Header Creep		Pipe Creep		Superheater Tube Creep	
	0.1	0.5	0.1	0.5	0.1	0.5
900	...	...	13,650	...	12,780	...
950	6490	...	6,950	10,580	3,820	5370
1000	3680	5151	3,140	4,920	...	2010
1050	...	2460	2,460	3,360	...	...
1100	...	...	...	2,010	...	...

Influnce of Metallurgical Changes

While it was difficult to determine the influence of individual elements, as the effect produced by one is sometimes obscured by the effect of others, the following general effects were observed by Jenkins and Tapsell, as reported to the B.E.A.I.R.A. in 1952:

CARBON—Although an increase in carbon content of steel from 0.1 to 0.6 per cent is accompanied by an increase in the tensile properties at room temperature, the creep resistance from room temperature up to 842 F is unaffected by variations in the carbon content within these limits.

MANGANESE—The presence of not less than 0.6 per cent manganese seems desirable in all carbon steels, as it appears to have a strengthening effect on the ferrite and, in addition, increases resistance to spheroidization.

SILICON—If the silicon content be plotted against the creep rate for the 65 carbon steels that were examined, an approximate parabolic relation between silicon content and creep rate can be shown. Generally, if the silicon content is less than 0.05 per cent, especially when the steel is killed with relatively large quantities of aluminum, a high creep rate is obtained and more than 0.2 per cent appears desirable to insure that the steel shall not have poor creep properties. Other factors, however, may overshadow the influence of silicon; and it is also found that in steels containing relatively high silicon content the aluminum and manganese contents tend to be correspondingly low.

ALUMINUM AND OXYGEN—A high aluminum content tends to produce a steel of high creep rate, although its effect is largely determined by the form in which it is present. Generally, if up to 0.5 lb of aluminum per ton is used for de-oxidation of a carbon steel, a creep rate of less than 2×10^{-6} per hr is obtained after five days at a stress of 8 tons per sq in. and a temperature of 842 F. Up to $1^1/_2$ lb of aluminum per ton can be tolerated in the de-oxidation of basic open-hearth carbon steel. However, when aluminum is used care must be taken in the de-oxidation process, and it has been found desirable that the contents of silicon and manganese should not be less than 0.2 and 0.6 per cent, respectively.

Oxygen determinations on 37 basic open-hearth steels containing 0.15 to 0.20 per cent carbon have suggested that good creep resistance is obtained if the oxygen content is not less than 0.10 per cent. With steels of higher carbon content lower oxygen appears desirable.

Aluminum is not normally used for the de-oxidation of acid open-hearth steels; but, as a matter of interest, use of aluminum in a special cast of acid open-hearth steel indicated that the treatment increased the oxygen content and produced a steel of abnormally high creep rate.

Abnormal Creep Properties in Carbon Steel

It has been noted that abnormally high creep rates are obtained with steels treated with large amounts of aluminum and that this treatment invariably produces a low oxygen content in the steel. Also, it has been observed that when steels having very high creep rates in the normalized condition are heat treated at temperatures up to 2012 F an increase in grain size occurs. This takes place rapidly in a narrow temperature range somewhere between 1652 and 2012 F, the exact range varying with the steel. Furthermore, after the high-temperature treatment these steels show greatly reduced creep rates, although a further heat treatment between 1382 and 1742 F again produces the previous high creep rate.

Steels having normal creep rates in the normalized condition do not show rapid increase in grain size on treatment at 2012 F, and their creep properties and structure are unaffected by this treatment; but the high-temperature treatment may have an adverse effect by increasing the subsequent rate of spheroidization.

Influence of Manufacturing and Service Conditions

It has been suggested that variations in finishing heat treatments given superheater tubes may have an influence on subsequent service behavior. Creep tests at 8 tons per sq in. and 842 F, continued for 8 days on tubes in various conditions of manufacture, have indicated that, provided the steel has not been treated with excessive quantities of aluminum (more than 2 lb per ton) for de-oxidation, there is little difference in the creep properties produced by the common finishing heat treatment which includes normalizing from 1697 F, close annealing from 1697 to 932 F, and subcritical annealing at 1157 F.

It has sometimes been questioned whether the cold-finishing pass given steam piping causes deterioration in creep properties of the steel. The creep properties of steam pipes in the hot-finished and cold-drawn conditions in chromium-molybdenum and vanadium-molybdenum steels have been compared. Creep tests carried out for a thousand hours at 4 tons per sq in. and 1067 F have indicated that, providing the steam

pipe is subsequently normalized above 1787 F, the cold-drawing operation has no deleterious effect on creep properties.

Steels subjected to prolonged heat treatment at temperatures below the lower critical point are subject to spheroidization of the carbides, and this change in the structure has been shown to be accompanied by reduction in creep resistance. Spheroidization is produced by heat treatment for a few hours at temperatures of the order of 1202 F. However, examination of sections removed from steam piping that has operated for long periods at temperatures of the order of 842 F has shown that some spheroidization can be produced in the metal at such temperatures after long service.

The effect on creep resistance of spheroidizing treatment has been confirmed by creep tests. Carbon steels, having both normal and abnormally high creep rates in the normalized condition, have shown that after a prolonged spheroidizing treatment of sixty days at 1202 F both steels exhibit similar creep strengths. The effect of spheroidizing treatments on the creep properties of alloy steels has not yet been examined by the Committee.

Cases of Intergranular Cracking Rare

One or two isolated cases of intergranular cracking in 0.5 per cent molybdenum steel piping have been reported in Britain during the last ten years. While the investigations did not reveal a common explanation of the failures, it was generally considered that the cause was concentration of stress on the pipe aided by residual stress in the material.

Some of the steels used for high temperature components of aircraft gas turbines are being considered for application in power stations using steam at 1050 F; and one steel, the 18/12/1 austenitic steel, has been adopted for steam piping and superheater tubing in a few experimental installations in Britain. The $2^1/_4$ per cent chromium–1 per cent molybdenum, ferritic steel, developed in the United States and used in some high-temperature power stations, has been adopted for other development plants in Britain. Tests are now in hand to obtain design data on the basis of long-time creep tests carried out on specimens machined from both steam pipes and superheater tubes of each of these steels.

For high metal temperatures resulting from use of steam at 1050 F and possibly above, development of steels with resistance to corrosion by superheated steam and to external scaling in the flue-gas atmosphere becomes of equal importance to resistance to creep.

ASME Spring Meeting Program

ENGINEERS from many parts of the United States and from Canada will participate in the Spring Meeting of The American Society of Mechanical Engineers to be held in the Deshler-Wallick Hotel, Columbus, Ohio, Tuesday through Thursday, April 28–30. Some 67 technical papers will be given by representatives of education, industry and government bureaus.

At the President's Luncheon on opening day the ASME president, Frederick S. Blackall, Jr., will speak on the subject: "For a Stronger, More Dynamic Society." Governor Frank J. Lausche of Ohio, will deliver the Roy V. Wright Lecture at the luncheon on Wednesday, while James F. Lincoln, president of The Lincoln Electric Company, Cleveland, will be the speaker at the banquet on Wednesday evening, on the subject "Incentive Management."

On Wednesday afternoon inspection trips will be made to the Jeffrey Manufacturing Company, Ternstedt Division of General Motors Corporation, Battelle Memorial Institute, the National Electric Coil Company, the Denison Engineering Company and the Diamond Power Specialty Corporation.

Portions of the program expected to be of interest to those in the steam power field include the following:

Tuesday, April 28, 9:30 a.m.

"Natural Gas Peak Load Problems in the Appalachian Area," by C. T. Konecny and B. J. Clarke, Columbia Gas System Service Corp.

"An Investigation of the Burning Characteristics of Pulverized Cinder," by John M. Allen, Battelle Memorial Institute.

"The Smokescope—An Instrument for Estimating the Density of Smoke Stack Effluent," by John P. Strange, Mine Safety Appliances Co.

"Some Theoretical Aspects of Centripetal Turbines," by R. L. Robinson, AiResearch Manufacturing Co.

"The Elastic-Fluid Centripetal Turbine for High Specific Outputs," by Rudolf Birmann, De Laval Steam Turbine Co.

Tuesday, April 28, 2:30 p.m.

"Rehabilitation of an Industrial Power Plant," by C. E. Morrow and R. F. Born, Western Electric Co.

"Overfire Air Installation at the Corners Creek Power Plant," by James W. Campbell and Richard J. Travis, The Detroit Edison Co.

Tuesday, April 28, 8:00 p.m., Junior Session

Subject: "Engineering—Opportunity Unlimited."

Speakers: G. F. Nordenholt, editor, *Product Engineering* and Everett S. Lee, editor, *General Electric Review*.

Wednesday, April 29, 9:30 a.m.

"Performance of Free Piston Gas Generators," by J. J. McMullen, USN, Bureau of Ships, and Warren G. Payne, U. S. Naval Engrg. Exp. Station.

"The Free Piston Type of Gas Turbine Plant and Applications," by J. J. McMullen, USN, Bureau of Ships, and Robert Ramsey, Cooper-Bessemer Corp.

"The Development of High Output Free Piston Gas Generators," by Frank M. Lewis, Massachusetts Institute of Technology, and Robert A. Lasley, Baldwin-Lima-Hamilton Corp.

"Heavy Duty Operation of Spreader Stokers," by M. W. Jones, Columbia-Southern Chemical Corp.

"Dust Emissions from Small Spreader-Stoker-Fired Boilers," by Elmer J. Boer, Bituminous Coal Research, Inc., and Charles W. Porterfield, Pocahontas Fuel Company, Inc.

"Mill Drying in Pulverizing High Moisture Coals," by W. C. Rogers, Riley Stoker Corp.

"Chemical Cleaning in Central Stations," by P. H. Cardwell, Dowell, Inc.

"Solubility of Oxygen in Water," by Leslie M. Zoss, Taylor Instrument Co., Spiridon N. Suciu, General Electric Co., and Wilmer L. Sibbett, Purdue University.

Thursday, April 30, 9:30 a.m.

"Ceramic Coated Low Alloys for Jet Engine Hot Parts," by John V. Long, Solar Aircraft Co.

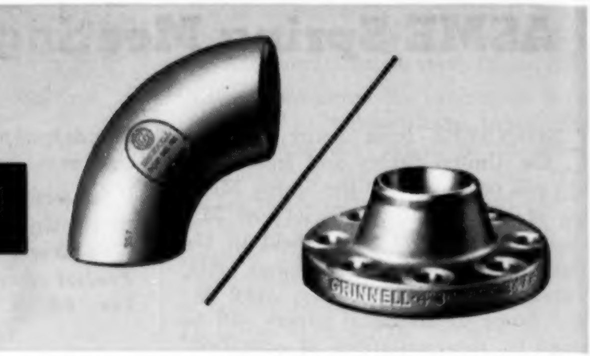
"The Mechanism of Disintegration of Liquid Sheets," by J. Louis York, H. E. Stubbs and M. R. Tek, University of Michigan.

"Thermodynamic Properties of Combustion Gases," by Gilbert S. Bahn, General Electric Co.

Thursday, April 30, 2:30 p.m.

"Industry's Stake in the Ohio Valley Pollution Control Program," by Edward J. Cleary, Ohio River Valley Water Sanitation Commission.

"Some Engineering Aspects of Air Pollution Control," by George W. Blum, Case Institute of Technology.



for trouble-free service

GRINNELL

STAINLESS STEEL WELDING FITTINGS and FLANGES

To help combat mounting costs in the installation and maintenance of piping systems where corrosive or certain other service conditions are involved, Grinnell offers a comprehensive range of welding fittings and flanges in stainless steel.

- **To prevent corrosive attack.**
- **To obtain adequate impact resistance at low temperatures and sufficient creep strength at high temperatures.**
- **To provide sanitary conditions.**
- **To avoid contaminating the product**

Grinnell welding fittings and flanges are available in types 304, 347 and 316. These are in the chromium-nickel grades known as "18-8". The corrosion resistant properties of stainless steels are primarily due to the chromium content which ranges from 17% to 20%. The addition of nickel in ranges from 7% to 14% improves the corrosion resistance as well as the properties at elevated temperatures. A molybdenum addition of 2% to 3%, as found in type 316, increases the resistance to sulphurous and phosphoric acids, brine and hypochlorite solutions, and improves the general resistance to other corrosive liquids, as well as improving the physical properties at elevated temperatures. A columbium addition of approximately 0.4% to 1.0%, as found in type 347, creates non-susceptibility to carbide precipitation which can cause intergranular corrosion.

In addition to stainless steel, Grinnell offers welding fittings and flanges in carbon steel, nickel, Inconel, Monel, aluminum and brass.

Write for new booklet giving complete data on Grinnell stainless steel welding fittings and flanges. No obligation.

stainless steel welding fittings
Types 304, 347, 316

DESCRIPTION	SCHEDULE†	PIPE SIZE, IN.‡
90° Long Radius Elbow 45° Long Radius Elbow 180° Long Radius Return Straight Tee	5s, 10s, 40s, 80s	½ to 12
Reducing Tee	5s, 10s, 40s, 80s	¾ to 12
Cross (Straight and Reducing)	5s, 10s, 40s, 80s	1¼ to 12
Concentric Reducer Eccentric Reducer	5s, 10s, 40s, 80s	¾ to 12
Lateral (Straight or Reducing)	5s, 10s, 40s, 80s	1 to 12
Cap	5s, 10s, 40s, 80s	½ to 12
Lap Joint Stub End-Long	10s, 40s, 80s	½ to 12
Lap Joint Stub End-Short	5s, 10s, 40s,	½ to 12

† 5s is Featherweight, 10s Lightweight, 40s Standard, 80s Extra Strong.
‡ Larger sizes available on special order.

stainless steel flanges

150 lb. and 300 lb. Steel Flange Standard *(Higher series available on application).*

DESCRIPTION	PIPE SIZE, IN.
Welding Neck Slip-on Lap Joint Threaded Socket Type Blind	½ to 24

150 lb. Corrosion Resistant Standard. *(For use with schedule 10s and 5s pipe. Rated at 150 psi at 500°F, 225 psi at 150°F, when used with full-faced gaskets).*

DESCRIPTION	PIPE SIZE, IN.
Buttwelding Slip-on Blind	½ to 12

GRINNELL

WHENEVER PIPING IS INVOLVED

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Coal Manual for Industry

By A. Wyn Williams

This is a very readable, moderately technical presentation of information of interest to anyone having to deal with the purchase, handling and burning of coal. The author's approach is inherently a descriptive one, and his efforts have been greatly aided by a judicious selection of commercial photographs illustrating almost all phases of the preparation and utilization of coal.

Starting off with chapters on the physical and chemical properties of coal and the combustion process, the book is then arranged to describe the various conventional coal-firing systems. Later chapters take up problems of air pollution, methods of coal preparation, the uses of lignite and anthracite, ways for handling the storing coal, and criteria for its purchase (including elements of typical contract specifications).

For the purchasing agent, the operating engineer who wishes to broaden his knowledge of coal utilization, or the engineering manager whose activities only are occasionally concerned with the design or operation of power plants, this book is to be highly recommended. To those who are actively engaged in the engineering aspects of design of steam power plants and component equipment, the author's approach may appear to be a little on the superficial side, notwithstanding his inclusion of quantities of useful data. The weakness of the book in this respect is best illustrated by the completely qualitative and descriptive nature of chapters on combustion and heat transfer. In other words the book is primarily for coal users and especially those who lack elementary technical understanding of the techniques and processes involved.

Priced at $5.50, the book contains 324 pages.

Advanced Mathematics in Physics and Engineering

By Arthur Bronwell

In preparing this text which is intended primarily for students in engineering and physics at the senior and graduate level, the author was guided by the following principles:

1. To present a fairly complete explanation of those areas of advanced mathematics which make up the principal analytical methods of physics and engineering.
2. To provide a broad perspective of the physical sciences through an understanding of a few fundamental mathematical formulations in those fields common to engineering and physics.
3. To offer an opportunity to become aware of the strong underlying unity in methods of mathematical analysis in many areas of physics and engineering.

The first five chapters take up complex numbers, infinite series, solutions of ordinary differential equations, and Fourier series. There follow chapters on partial differentiation, vibration phenomena, Lagrange's equations and vector analysis. Subsequent chapters are concerned with wave equation solutions, heat flow, fluid dynamics, electromagnetic theory, functions of a complex variable, and Laplace transformations.

Emphasis throughout the text has been placed upon applications in dynamics, rather than in statics. Each chapter includes a set of problems (with answers) designed to supplement the text material and to acquaint the student with some of the references also listed in each chapter.

This is a book well worth serious self-study by engineers whose mathematical education ended at the calculus level. Mastery of the techniques of analysis included in the text should be of considerable aid in understanding theoretical considerations of advanced mechanics, thermodynamics and some areas of modern physics.

There are 475 pages and the book sells for $6.

Atmospheric Pollution—Its Origins and Prevention

By A. R. Meetham

Much has been written, both here and abroad, in the postwar period concerning atmospheric pollution; many engineering society papers have been presented on the subject; and new legislation has been adopted in many localities. In view of this active and widespread interest, books on the subject always command attention.

The book under review, while representing British practice as concerns equipment and measurement of pollutants in certain industrial areas, nevertheless treats the subject broadly enough

to be of assistance to those confronted with the problem. The department of Scientific and Industrial Research and the Fuel Research Station of the British Government have been the source of much information.

Commenting upon the fact that smoke and atmospheric pollution is a matter of long standing, the text cites an ordinance enacted by Parliament in 1273, as a result of widespread complaints, which prohibited the burning of coal in London. Obviously this was later relaxed.

It is estimated that 8 million tons of atmospheric pollution from the burning of fuels is produced yearly in Britain and that 1 ppm of pollution is sufficient to render the atmosphere unpleasant. The reactive pollutants are dominated by sulfur compounds, carbon monoxide, hydrochloric acid and compounds of fluorine, whereas the very fine particles usually represent smoke and the coarser particles of mineral matter and ash.

The contents include chapters on the origin of various natural fuels, their classification, rank and characteristics; also similar information on artificial fuels. Those on boilers and industrial furnaces, together with their operation, deal largely with British practice, as do the charts on pollution distribution as taken from official surveys; but the latter are representative of climatic conditions and industrial concentrations. Photographs are included of physical damage to buildings, devices for measuring pollution; and preventative measures are discussed at some length. A final chapter deals with representative laws and their administration in both England and the United States.

There are 268 pages, $5^1/_2 \times 8^1/_2$ in., and the price of the book is $4.90.

Specifications for Steel Piping

This compilation sponsored by ASTM Committee A-1 on Steel contains in approved form the 56 widely used ASTM specifications for carbon-steel and alloy-steel pipe and tubing, including stainless. Covered are material for pipe used to convey liquids, vapors and gases at normal and elevated temperatures; boiler, superheater and miscellaneous tubes; still tubes for refinery service; heat-exchanger and condenser tubes. To make the volume more complete there are also included specifications for the following materials used in pipe and related installations: castings; forgings and welding fittings; bolts and nuts. The ASTM standard classification of austenite grain size in steels (E19) with two sets of charts; also the American Standards

covering wrought steel and wrought iron pipe (B36.10) and stainless steel pipe (B36.19) are a part of the book.

New specifications cover: quenched and tempered alloy steel bolts and studs with suitable nuts; electric-fusion-welded austenitic chromium-nickel alloy steel pipe for high-temperature service; iron-chromium and iron-chromium-nickel alloy tubular centrifugal castings for general applications.

Sixteen emergency alternate provisions applying to specifications in this compilation are printed in a pink section at the back of the book. These are issued by the American Society for Testing Materials in accordance with a special procedure in the interest of expediting procurement or conservation of materials during the period of National Emergency. They are intended for use where they may be considered by the purchaser of the material as a permissible alternate for the specific application or use desired.

The grade designations in all tubular specifications, as well as specifications covering forgings used in conjunction with pipe at high temperature, have been reviewed and correlated.

These specifications are in widespread use and the book should be of distinct service to those concerned with pressure piping, power generating, the petroleum field, distribution of water, gas, oil and the like, and to individuals in industries where these materials are important.

The book has 394 pages, with heavy paper cover, and is priced at $3.75.

The Elements of Nuclear Reactor Theory

By Samuel Glasstone and M. C. Edlund

Based on the course in nuclear reactor theory given at Oak Ridge School of Reactor Technology, this fundamental text has been prepared under the auspices of the Atomic Energy Commission in order to provide essential information for engineers and scientists who plan to prepare themselves to work with reactors for producing power and for other purposes. The senior author, who is a consultant for the A.E.C., also wrote the "Sourcebook on Atomic Energy" several years ago, while Mr. Edlund is a physicist in charge of a course in nuclear reactor theory at Oak Ridge.

Four introductory chapters entitled Nuclear Structure and Stability, Nuclear Reactions, Production and Reactions of Neutrons, and the Fission Process have been provided. A thorough understanding and mastery of their content is essential if the meaning of the remainder of the book is to be grasped. At this point it should be made clear that the average mechanical engineer is unlikely to have studied many of the

concepts of modern physics covered in these introductory chapters. The reading of this book could be made more meaningful by a parallel study of texts on nuclear physics (at an intermediate level) and on advanced mathematics, including differential equations and vector analysis.

Subsequent chapters take up the diffusion and slowing down of neutrons, homogeneous and heterogeneous reactors, reactor control, perturbation theory and transport theory. Material included in these chapters is devoted to the fundamental principles involved in the calculation of the critical conditions for thermal neutron chain-reacting systems. The main section does have the advantage of being the most complete exposition to date of reactor theory from a single unified point of view.

Actually the book points to a situation that engineering educators will sooner or later have to face if nuclear technology is to take its place alongside conventional forms of power generation. That is the problem of comprehending new material derived from highly theoretical considerations of advanced physics, a task which requires a more rigorous training in physics and mathematics than engineers generally receive. If the book is any indication, the design of reactors for nuclear-energy power plants will be based from the start on rationally developed parameters, as distinguished from the empirical approach that historically has provided the impetus for improvements in the design of conventional plants. In other words, knowledge of theoretical physics precedes nuclear plant design, whereas steam engines were in operation for many years before the science of thermodynamics developed to the point of influencing markedly steam plant design.

This basic and significant text, which is concerned with the theory of nuclear reactors, as distinguished from the problems of designing and building a pile, contains 416 pages and sells for $4.80.

Surface Condenser Standards

The Heat Exchange Institute has just issued a new edition of its 20-page book, "Standards for Steam Surface Condensers." It is a revision of the book on the same subject issued in 1939 and 1940, and is one of a series of eight separate publications on different pieces of heat-exchanger apparatus.

The book has been completely rewritten and revised. Definitions have been clarified and under the heading "Heat Transfer Rates," new material is introduced which reflects results of extensive tests conducted at Lehigh University, including corrections in heat

transfer for different tube materials. Performance curves have been included to illustrate more nearly actual maximum performance. A new section of recommended sizes is included. The recommended vacuum pump capacities have been revised and capacities for rapid evacuation are included.

The object of the Standards is to help the purchaser of condensers by defining essential terms and by setting up definite standards of heat transfer rates and performance guarantees. It also contains material which is essential to engineers when writing specifications or designing surface condensing equipment.

Copies may be obtained from the Heat Exchange Institute, 122 East 42nd Street, New York 17, N. Y., at two dollars each (within the United States and possessions).

Reserves of Petroleum and Natural Gas in U. S.

A joint announcement by the American Petroleum Institute and the American Gas Association, issued March 11, shows that proved reserves of liquid petroleum and natural gas reached new all-time peaks in 1952 despite record high production levels.

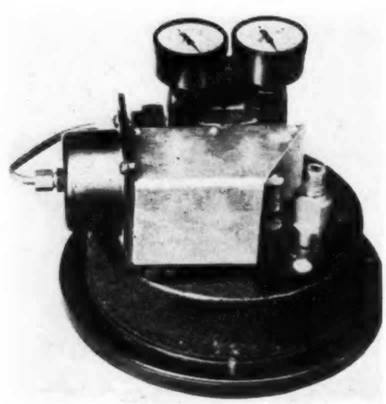
The proved reserves of liquid petroleum reached 32.9 billion barrels as of last December 31 and those of natural gas rose to 199.7 trillion cubic feet. These figures represent the known supplies buried in the ground as determined by continuous drilling, but do not include estimates of oil and gas that may later be found under the vast acreage of ground in the United States known to be favorable to the accumulation of oil and gas but as yet untested.

Production of both oil and natural gas broke all records in 1952, the output of liquid petroleum having amounted to 2.5 billion barrels, an increase of 60 million barrels over 1951, and natural gas 8.6 trillion cubic feet, an increase of 672 billion cubic feet over 1951.

NEW EQUIPMENT

Pressure Pneumatic Transmitter

An instrument combining a pressure gage of highest quality with a reliable pneumatic transmitter has been announced by Penn Industrial Instrument Corp., 4110 Haverford Ave., Philadelphia 4, Penna. The output pressure of the transmitter varies from 3 to 15 lb (or 5 to 25 lb if specified) regardless of the range of pressure being measured. Used with either full-size recording re-



ceivers or miniature indicating instruments, these units provide safety and convenience where high pressure, corrosive, toxic, inflammable or other hazardous fluids are being used. They permit the use of low-pressure air piping to bring pressure indication or recording up to distances of 100 ft. The transmitting instrument is compact and suitable for panel, pedestal or wall mounting.

Unit Heaters

L. J. Wing Mfg. Co., Linden, N. J., has made available a new line of unit heaters and heater sections which incorporate the Hynes electric heating element. The electric heaters are obtainable in sizes ranging from 13,600 to 204,000 Btu per hr for the unit heaters, the smallest unit discharging at a rate of 235 cfm and the largest at 3600 cfm. Three types are being built and are suitable for application to a run of duct, for process heating or replacing exhausted air with fresh tempered air, where steam or hot water is not available or economical.

Insulating Blocks

The Eagle-Picher Co., 900 American Bldg., Cincinnati 1, Ohio, has developed a new process for producing industrial high-temperature insulating blocks, which are known as "P.V." (Pressure Vacuum) blocks. Suitable for temperatures up to 1900 F, they are reported to represent an improvement over ordinary mineral wool insulating blocks because of their ability to withstand higher temperatures, greater breaking strength and ease in handling. By means of a combination of vacuum and pressure techniques which cause the mineral wool fibers to become felted and compressed, the blocks are given improved physical properties.

Flow Meter

The Hays Diaflow Meter is a newly designed low differential flow meter for measuring air flow, gas flow or recording the ratios of air flow to gas flow. It is especially adaptable for industrial furnaces and sewage disposal plants and utilizes the pilot method of operation in which no load is placed on the measuring element. Adapted to measure static pressures up to 10 lb and differential pressures up to 20 in. of water, the meter is available from The Hays Corporation, Michigan City, Ind.

Combustion Analyzer

A commercial, portable all-electric combustion analyzer which measures carbon dioxide (0–20 per cent), temperature (100–1000 F) and draft (0–0.3 in. water) on one meter is announced by Victory Engineering Corp., Springfield Road, Union, N. J. Powered by a dry

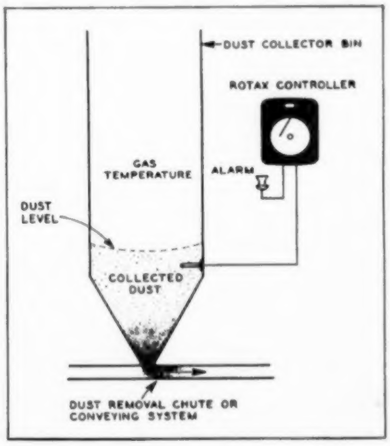
cell battery, features of this Model 140-C include: glass-coated electronic thermistor; gas analysis cell with built-in temperature compensator, filter drier, compensated thermocouple lead and two 30-in. probes. Flue gas temperatures are taken at the same point as CO_2 measurements, and a series of readings may be made without moving probes.

Plastic Coating

A plastic coating for use as both protection and color identification on insulated-refrigerant, cold-water, steam and other lines has been developed by the Armstrong Cork Co., Lancaster, Penna. Known as Insulcolor, it can be either brushed or sprayed on and will withstand temperatures to 160 F without cracking, shrinking or crazing. It is available in white and six colors, has high resistance to bumping and abrasion, and has water-resisting properties which make it suitable for either inside or outside applications. Insulcolor can be applied over standard asphaltic finishes without danger of bleeding through or it can be used as an adhesive for pasting down canvas, asbestos and other lagging cloths.

Dust Level Control

Fly ash collected in an electrostatic precipitator is automatically measured and the bin level controlled by a single instrument, a Model 40 Rotax controller manufactured by the Foxboro Company, Foxboro, Mass. A temperature bulb, mounted inside the precipitator,



normally senses the higher temperatures of the flue gases from which the dust is precipitated. When the dust deposit covers the bulb (acting as insulation) the controller, responding to the resulting lower temperature, completes an electrical circuit through its contacts to sound an alarm and alert the operator.

Console Indicator

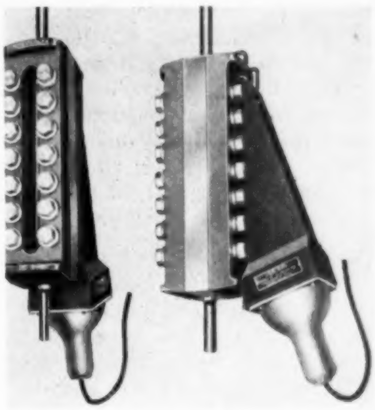
An electronic console indicator which saves panel space and permits an operator to scan up to 200 thermocouple temperatures as fast as he can log them has been developed by the Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Penna. It consists of an ex-

ecutive-type desk with a mounting which houses a specially adapted Speedomax Indicator and flanking switch panels. The mounting extends only 13 in. above the desk, permitting the operator an unobstructed view of the main control room panel. Console switch panels, which are removable, hold as many as 100 toggle-type switches for 200 in-

dicator or 100 indicator and recorder readings. Terminal boards are centrally located and easily accessible through wide-swinging doors on the back of the console. In placing the unit in operation, the user need only connect thermocouple extension lead wires and the line voltage supply.

Gage Illuminators

For greater visibility of flat-glass water-level gage readings the Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Penna., offers the Yarway Type "M" illuminator which uses a 100-watt sealed-in beam mercury-vapor lamp as its source of light. Producing about



twice the amount of light for the same power input, the greenish blue color of the emitted light aids in increasing visibility. The mercury vapor rays also have the ability to penetrate foreign deposits on the mica, resulting in longer gage service life.

Nuclear Power Produced at Oak Ridge

The production of useful amounts of electric power by nuclear energy has been achieved from successful operation of a new type of reactor—an experimental homogeneous reactor—at Oak Ridge National Laboratory of the Atomic Energy Commission.

On February 24, scientists brought a pilot-model of the unique reactor system up to its full design power of 1000 kw of heat output. The reactor steam then was switched to a turbine-generator and about 150 kw of electricity was produced.

Capable of producing both fissionable material and electric power, the small homogeneous reactor was developed at Oak Ridge Laboratory, which Union Carbide and Carbon Corp. operates for the AEC. However, this reactor was not designed to produce economic electric power.

The first demonstration of electric power production by a reactor occurred in December 1951 at the National Reactor Testing Station in Idaho with the operation of the experimental breeder reactor, developed by Argonne National Laboratory.

In the homogeneous reactor, a single homogeneous solution serves as fuel, moderator and coolant. The heat generated by the nuclear reaction of the uranium fuel in the solution is removed by pumping the hot radioactive liquid through a heat-exchanger or boiler which produces steam to drive a turbine-generator.

A homogeneous type reactor was built in 1944 at Los Alamos Scientific Laboratory in New Mexico, and another is nearing completion at North Carolina State College. However, these units are low-power research reactors. The one at Oak Ridge is the first to operate at a temperature and power high enough for production of steam to run a standard industrial turbine-generator.

Oregon ASME Section to Sponsor Boiler Code Meeting

A joint meeting of the Boiler Code Committee of the American Society of Mechanical Engineers and the National Board of Boiler & Pressure Vessel Inspectors is to be held at the Multnomah Hotel in Portland, Oregon, on April 27, 28, 29 and 30.

General Chairman for the event, Mr. Ed Rowan of Portland Gas & Coke Company, announces a full schedule of Code & Inspection sessions, and panel discussions with particular emphasis on Section VIII of the Boiler Code.

The National Board of Boiler and Pressure Vessel Inspectors is made up of the Chief Inspectors of the States, Cities and Canadian Provinces that have adopted the rules and regulations of the ASME Boiler Code. It consists of 55 members representing 32 States of the Union, various Cities and Canadian Provinces.

The Boiler Code Committee of the American Society of Mechanical Engineers consisting of 24 appointed ASME members compiles the Boiler & Pressure Vessel Codes, and makes interpretations of the Code as requested by the National Board and others.

C. O. Meyers, Secretary-Treasurer of the National Board, and H. B. Oatley, Chairman of the Boiler Code Committee, are high in their praise of the results of the annual joint meetings, both feeling that better cooperation and understanding between those who write the Code, those who administer it, and the manufacturers following the specifications, has improved greatly as a direct result of the joint meetings.

Anthracite Conference

The Eleventh Annual Anthracite Conference, sponsored jointly by Lehigh University and the Anthracite Institute will be held at the Packard Laboratory of that school in Bethlehem, Pa. on May 7 and 8. A diversified program has been planned, including the following papers:

"Pyramid Grates", by Henry K. Eilers of the Pyramid Grate Co., New York.

"Stoker Design—A Challenge to the Coal Business", by L. C. Dubs, of Canton Stoker Corp.

"Some Aspects of Air Pollution", by Dr. Louis C. McCabe, chief of the U.S. Bureau of Mines Fuels and Explosives Division.

"Spectrographic Analysis of Anthracite for Trace Elements", by Dr. C. C. Wright, R. C. Nunn and H. L. Lovell, all of Pennsylvania State College.

"Anthra Aid"—a new carbonaceous filter aid, by Dr. R. C. Johnson of Anthracite Institute.

"High Btu Gas from Anthracite", by L. L. Newman of the U. S. Bureau of Mines.

"Active Carbon—Its Preparation and Application", by John W. Hassler of West Virginia Pulp and Paper Company.

"The Blending of Anthrafines in Coke Preparation", by J. D. Clendenin and Joseph Kohlberg.

"A Fuel Economy Survey of New York City Operated Fuel-Burning Plants", by Kenneth E. Sanger of Percival R. Moses & Associates.

"A Mining Research Program for Anthracite", by David J. Crawford and W. J. Parton.

"Quality Control of Product and Raw Feed", by David B. Baird.

Personals

James N. Landis has been elected a vice president of the Bechtel Corporation, San Francisco, well-known engineers and constructors on the Pacific Coast. Following many years with the Consolidated Edison Company of New York, he was appointed chief engineer of the Power Division of Bechtel in 1948.

Stanley Stokes, vice president and chief engineer of the Union Electric Company, St. Louis, on March 21 was recipient of the Missouri Honor Award for distinguished service in engineering. Presentation was made by Dean Huber O. Croft at a convocation of the University of Missouri.

Announcement has been made of the affiliation of the consulting engineering firms of Baker & Spencer Inc. and Frederic R. Harris Inc., both of New York and well known in the industrial power field. **E. J. Quirin** is president and **C. G. Spencer** vice president of the affiliated companies.

George D. Ellis, vice president and controller of Combustion Engineering, Inc., has recently been elected a director. Joining the organization in 1915, he was successively auditor, controller and secretary, also becoming a vice president in 1948.

Alexander Gobus, for the last ten years chief metallurgist and director of non-destructive testing with Sam Tour & Co., has recently joined the North American Philips Company as head of a new non-destructive testing department. Mr. Gobus has long been a recognized authority on industrial fluoroscopy and radiography.

Ernest H. Peabody, president of Peabody Engineering Corp., New York, has been chosen chairman of the New York Engineering Section of the "Crusade for Freedom" which under the national direction of Charles E. Wilson is pushing a campaign for expansion of radio-free Europe and Asia.

Paul O. Kock has become associated with Bituminous Coal Research, Inc. at Columbus, Ohio, in connection with research and development of industrial heat and power projects. For the last six years Mr. Kock was chairman of the physics department of Ohio Mechanics Institute, prior to which he had extensive experience in steam power plant work.

C. C. Zimmerman, vice president and chief engineer of the Benjamin F. Shaw Co., Wilmington, Del., was recently named executive vice president of that company.

Business Notes

Dowell Inc. has promoted L. E. West to the position of general sales engineer at the Company's headquarters in Tulsa, Oklahoma. He will be succeeded as district sales engineer at the Houston Office by H. B. Green.

The Permutit Company, manufacturer of ion-exchange water-conditioning equipment, has removed its Los Angeles, California, sales office to 302-B South Brand Blvd., Glendale, California.

American Blower Corporation has appointed J. W. Ruff director of purchases succeeding R. S. Reade who has been made director of purchases for the American Radiator and Standard Sanitary Corporation, the parent organization.

National Aluminate Corporation, Chicago, recently announced a number of promotions within its organization. These include three assistant vice presidents, namely, H. R. Powers, Dr. D. G. Braithwaite and Gage Averill, and James Rush from district manager in the Pittsburgh area to division manager of the East Nebraska-Iowa territory. Mr. Rush replaces the late Clarence C. Simpson.

Republic Flow Meters Company, Chicago, appointed Thomas E. Bell as sales manager effective April first. For the last 20 years Mr. Bell was manager of the southern territory with headquarters in Atlanta, Georgia, where he is being succeeded by Thomas Waldrop.

Builders Iron Foundry, Providence, Rhode Island, announces the election of Earl H. Bradley as president to succeed Henry S. Chafee who, however, will continue as treasurer. A concurrent announcement named George W. Kelsey as the new president of Builders-Providence, which is the instrument and meters division of the former.

Chain Belt Company of Milwaukee, manufacturer of conveyors, sprocket chains and process equipment, has appointed Gilbert J. Schuelke as assistant sales manager of its chain and transmission division.

Fairfield Engineering Company, Marion, Ohio, has appointed the J. D. Wilson Company of Milwaukee as its representative in Wisconsin for the design, construction and servicing of coal-and ash-handling equipment.

Engineering School Enrollments

Illinois Institute of Technology, in Chicago, enrolls more engineering students than does any other educational institution in America. It has 4,621 undergraduates and 920 graduate students. This fact is revealed in the recently released report of the American Society for Engineering Education.

Second and third largest engineering enrollments in the nation are at Brooklyn Polytechnic Institute and Purdue University respectively. The former has 3,190 undergraduates and 1,050 graduate engineering students whereas the latter has 3,808 undergraduates and 313 graduate students.

The twelve other educational institutions of the fifteen which enroll the most engineering students, in order of size of their respective registrations, are: University of Illinois, College of the City of New York, Massachusetts Institute of Technology, New York University, Georgia School of Technology, University of Cincinnati, Penn State College, Newark College of Engineering, Texas A. & M. College, Rensselaer Polytechnic Institute, Ohio State University, and Iowa State College.

Obituary

John C. Parker, retired vice president of Consolidated Edison Company of New York and well known in the field of utility research, died at Brooklyn Hospital on March 22, in his 74th year.

A graduate of the University of Michigan in mechanical engineering with the class of 1901, he served an apprenticeship with the General Electric Company and later became an instructor at Union College in association with the late Charles P. Steinmetz. He later served as head of the Department of Electrical Engineering at the University of Michigan and joined the Brooklyn Edison Company in 1922 as electrical engineer. He became president of that company in 1932 and four years later, when it was merged with Consolidated Edison Company, he became vice president in charge of research. In 1940 he was honored by the University of Michigan with the degree of Doctor of Engineering. He was also a past president of the American Institute of Electrical Engineers and a Fellow of the ASME.

New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Fan Manual

A limited number of copies of a 68-page, plastic-bound service manual prepared by the Clarage Fan Company are available for those who have fan problems. This attractive and effectively illustrated manual contains information on fan designations, methods of installation and alignment, provisions for initial operation, maintenance methods, and couplings and drives. Other parts take up heavy-duty industrial fans, propeller fans, air-conditioning units, and unit heaters.

Demineralizers

Penfield Manufacturing Co. has prepared a catalog sheet describing fully automatic mono-column demineralizers. It includes a photograph and schematic diagram, combined with part descriptions, sample specifications and performance data.

Automatic Coal Scale

A 16-page, two-color bulletin covering the H-39 automatic coal scale has been published by the Richardson Scale Co. It is divided into five sections giving construction and operating details. There are 27 photos and line drawings which illustrate scale features and a two-page, four-view drawing giving full dimensions for models having capacities of 15 and 40 tons per hour.

Totalizing Meter

For accurate measurement of water, gas, air, sewage, sludge and industrial liquors and Simplex Valve and Meter Co. has developed the Type H-Meter which is described in a 20-page bulletin prepared by the company. Information is included on the construction, operation, capacities and specifications for the meters, which indicate, record and totalize measurements.

Roller Chains

A 54-page bulletin on Baldwin-Rex roller chains and sprockets has been published by Baldwin-Duckworth, division of Chain Belt Co. One section explains methods of selecting standard roller chain drives and comprises formulas, tables and examples illustrating this procedure. Another deals with flexible couplings and includes power ratings, typical dimensions and prices.

Oil and Gas Burners

Coen Company has made available Bulletin P-152, an 8-page publication illustrating and describing the Pac-O-Matic oil, gas and combination gas and oil burners. Discussed in the bulletin are burner component parts, available models and sizes, and typical performance.

Precipitators

A 4-page bulletin providing conveniently arranged information on design features of Cottrell electrostatic precipitators for the paper industry has been announced by Research Corporation. A diagram and a cutaway view aid in showing operating and construction details.

Glucosates

D. W. Haering & Co. have published a 4-page bulletin listing glucoside derivatives useful as organics in scale and corrosion control. Mention is made of eleven glucosates suitable for a variety of water control problems.

Cast Steel Valves

A 56-page catalog, No. 12-C, covering their line of cast steel valves has been published by Edward Valves, Inc. Included is information on globe, angle and check valves in 300, 600, 900 and 1500 lb pressure classes. It also has data on material specifications, preparation of welding ends, flange facings, and pressure-temperature ratings.

Centrifugal Fans

An 8-page booklet on airfoil centrifugal fans is available from the Sturtevant Division of the Westinghouse Electric Corp. A graph of certified horsepower, effiiciency and pressure ratings of airfoil fans is presented, and design features which contribute to these ratings are discussed. Mention is also made of the construction features of housings, wheels and shafts and bearings of heavy-duty airfoil fans.

Soot Blowers

Bulletin 1004 prepared by the Copes-Vulcan Division of Continental Foundry & Machine Co. discusses fifteen central station installations of Vulcan automatic-sequential soot-blower systems. Power and reheat boilers with capacities up to 1,370,000 lb of steam per hour, pressures to 1925 psig and temperatures to 1055 F are included. There are 32 pages in the bulletin which describes air- and motor-driven units using air or steam as the blowing medium.

Power Distribution

A bulletin containing useful information on power-distribution practices in large and small plants has been announced by the General Electric Co. Designated as GEA-5900, the 28-page publication covers utility distribution practices; selection of primary voltage; application of primary switches, circuit breakers and cables; and types of load-center distribution systems. Other suggestions are made on the use of capacitors and rectifiers.

Temperature Transmitter

The Swartwout Company has made available Bulletin A-706, a 4-page publication describing the T2T temperature primary-element transmitter. This is a resistance-thermometer temperature element designed to operate in connection with the Company's Autronic controlling system. The bulletin is illustrated with photographs, line drawings and schematic diagrams showing principles of operation.

Records and Indicators

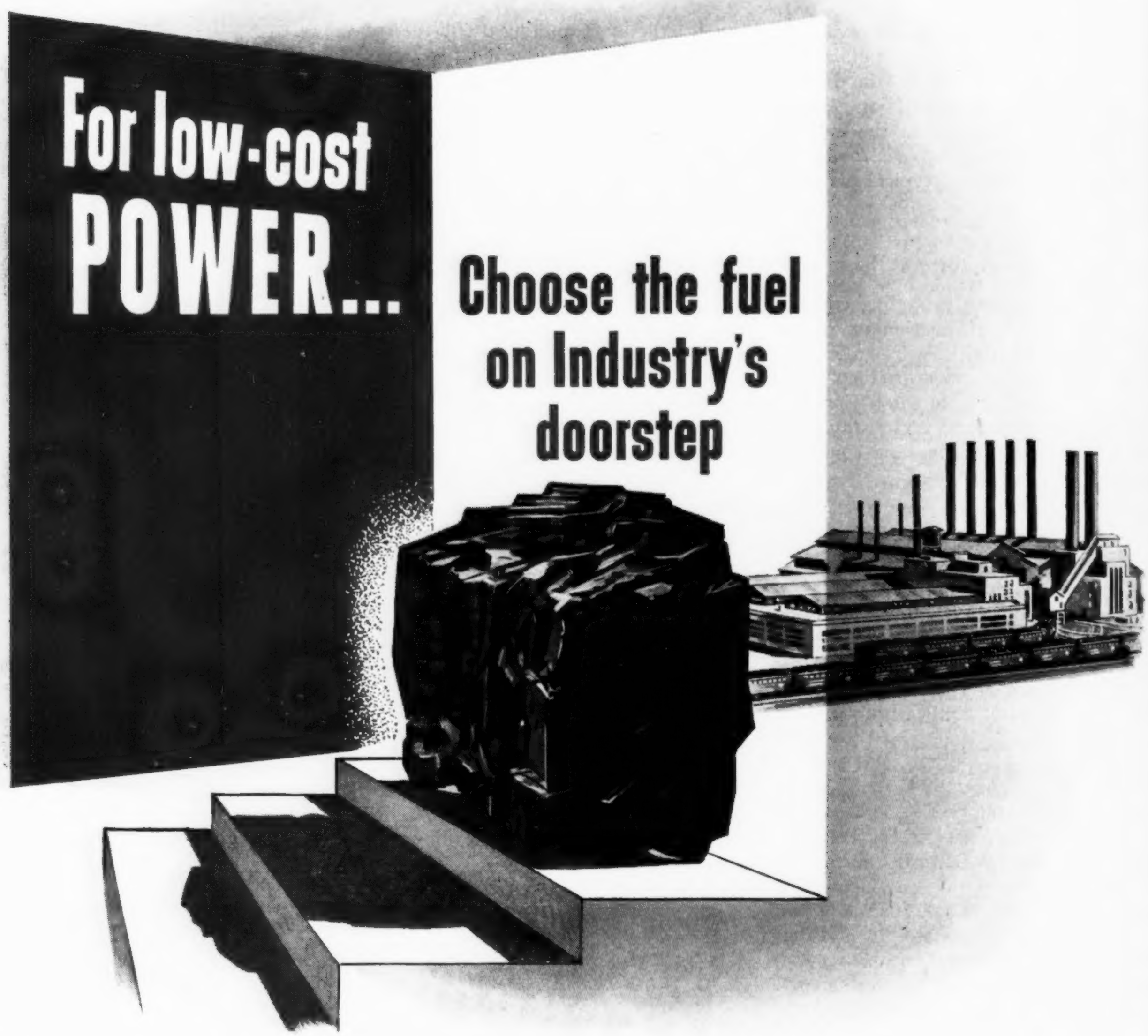
Catalog 1520, a 48-page publication prepared by the Brown Instruments Division of Minneapolis-Honeywell Regulator Co., contains factual information on ElectroniK non-control precision instruments. It presents detailed specifications for particular models and information on special adaptations useful in connection with specific research problems. Other sections of the bulletin take up measuring elements and typical laboratory equipment using these instruments.

Temperature Controller

Data concerning moderate-priced electronic instruments for two-position or proportional control are available in a 20-page catalog prepared by the Leeds & Northrup Company. It shows how three types of Electromax temperature controllers are used to regulate temperatures up to 1000 F and how similar conductivity controllers are being utilized for checking condensate purity. This well-written publication explains how three types of temperature control may be obtained and tells of reliable methods to control conductivity.

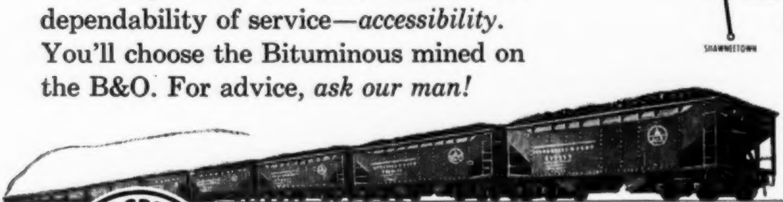
Liquid Level Gages

Jerguson Gage & Valve Co. has made available a 4-page bulletin explaining the design, construction and use of reflex-type liquid-level gages. Mention is made of the four pressure groups for which the gages are made, and a concluding section lists special applications.



Coal is where you find it. Fortunately, however, a large share of the nation's operating Bituminous mines are located in Baltimore & Ohio territory—*economically accessible to America's great industrial plants*. The Bituminous mined here—practically on Industry's doorstep—is of excellent quality and in wide variety; whatever your specific need, there are B&O coals to meet it. Furthermore, the supply is *inexhaustible*—you can count on an *unlimited* reserve of B&O Bituminous, even in emergencies, for centuries to come.

When you consider fuel, consider cost—dependability of service—*accessibility*. You'll choose the Bituminous mined on the B&O. For advice, *ask our man!*



BITUMINOUS COALS FOR EVERY PURPOSE

BALTIMORE & OHIO RAILROAD

Constantly *doing things*—better!